Applied Radiation and Isotopes 128 (2017) 75–85

Contents lists available at ScienceDirect

Applied Radiation and Isotopes

journal homepage: www.elsevier.com/locate/apradiso

Use of spectral gamma ray as a lithology guide for fault rocks: A case study from the Wenchuan Earthquake Fault Scientific Drilling project Borehole 4 (WFSD-4)

Ahmed Amara Konaté[a,e,*], Heping Pan[a,**], Huolin Ma[a], Zhen Qin[a], Bo Guo[a], Yao Yevenyo Ziggah[c], Claude Ernest Moussounda Kounga[d], Nasir Khan[a], Fodé Tounkara[b]

[a] Institute of Geophysics and Geomatics, China University of Geosciences (Wuhan), Lumo Road 388, Postal code, 430074 Wuhan, Hubei, China
[b] Faculty of Earth Resource, China University of Geosciences (Wuhan), Lumo Road 388, Postal code, 430074 Wuhan, Hubei, China
[c] Faculty of Information Engineering, China University of Geosciences (Wuhan), Lumo Road 388, Postal code, 430074 Wuhan, Hubei, China
[d] Resources Planning & Developing Dept., Baosteel Resource Co., Ltd, No. 568, East Dongdaming ing Road, Hongkou District, Postcode, 200080 Shanghai, China
[e] Institut Supérieur des Mines et Géologie de Boké, BP, 84, Boké, République de Guinée

HIGHLIGHTS

- Lithology and fault rocks show a variability of SGR logs responses and clay minerals.
- The cross plot and statistical multi log analysis are effective in characterizing lithology and fault rock.
- SGR log together with others logs would help understand earthquake mechanism.

ARTICLE INFO

Keywords:
Spectral gamma-ray logs
Wenchuan earthquake
Well log interpretation
Fault rocks
Clay minerals
Lithology

ABSTRACT

The main purpose of the Wenchuan Earthquake Fault Scientific drilling project (WFSD) was to produce an in-depth borehole into the Yingxiu–Beichuan (YBF) and Anxian–Guanxian faults in order to gain a much better understanding of the physical and chemical properties as well as the mechanical faulting involved. Five boreholes, namely WFSD-1, WFSD-2, WFSD-3P, WFSD-3 and WFSD-4, were drilled during the project entirety. This study, therefore, presents first-hand WFSD-4 data on the lithology (original rocks) and fault rocks that have been obtained from the WFSD project. In an attempt to determine the physical properties and the clay minerals of the lithology and fault rocks, this study analyzed the spectral gamma ray logs (Total gamma ray, Potassium, Thorium and Uranium) recorded in WFSD-4 borehole on the Northern segment of the YBF. The obtained results are presented as cross-plots and statistical multi log analysis. Both lithology and fault rocks show a variability of spectral gamma ray (SGR) logs responses and clay minerals. This study has shown the capabilities of the SGR logs for well-logging of earthquake faults and proves that SGR logs together with others logs in combination with drill hole core description is a useful method of lithology and fault rocks characterization.

1. Introduction

In deep drilling, borehole logging has long played a significant part in the evaluation of the drilled rock (Engell-Jensen et al., 1984). Logging data are processed and interpreted to provide a variety of information for geoscience research. Borehole logging includes acoustical, electrical, and nuclear methods. A complete set of logs have been used in scientific drilling research to provide information on lithology and rock properties. Well logs exploit two kinds of nuclear radiation, Gamma rays and Neutrons. The former is our concern here to study the Spectral gamma ray (SGR) log responses of the Wenchuan Earthquake Fault Scientific Drilling project borehole 4 (WFSD-4).

Access to the interior of active faults is of fundamental importance to the understanding of earthquake slip (Kinoshita et al., 2014). Over the years there has been a continuous research interest in Earthquake science. Studies have shown that geophysical logs and drill well core description in active faults can provide reliable evidence for understanding earthquake physical properties (e.g. Li et al., 2013, 2014,

* Corresponding author at: Institute of Geophysics and Geomatics, China University of Geosciences (Wuhan), Lumo Road 388, Postal code, 430074 Wuhan, Hubei, China.
** Corresponding author.
E-mail addresses: konate77@yahoo.fr (A. Amara Konaté), panpinge@163.com (H. Pan).

http://dx.doi.org/10.1016/j.apradiso.2017.06.038
Received 14 January 2017; Received in revised form 23 June 2017; Accepted 24 June 2017
Available online 28 June 2017

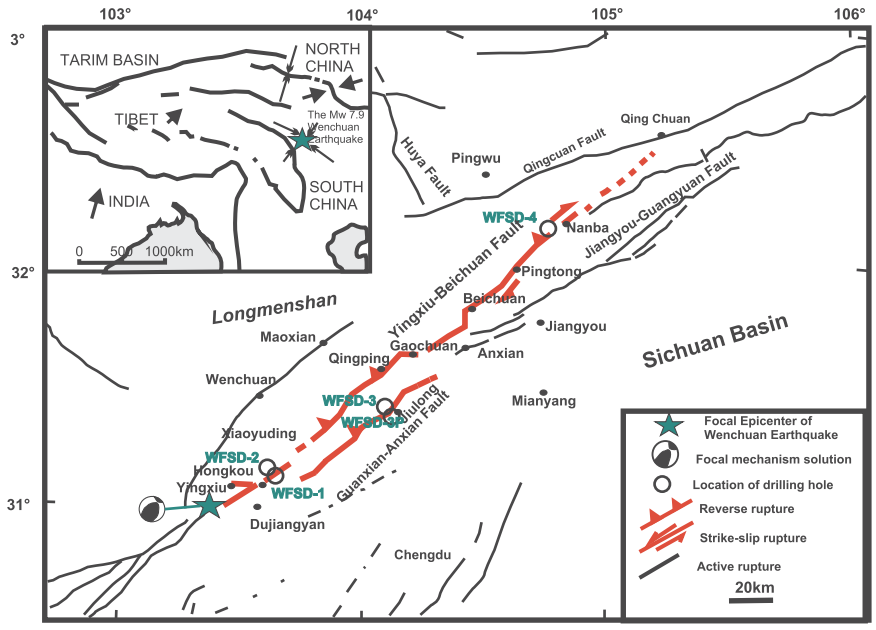

Fig. 1. Well site schema of WFSD, modified from Nie et al. (2013). Wenchuan earthquake surface rupture zone (red line). WFSD-1 drill hole and WFSD-2 drill hole are located in the southern segment of Yingxiu-Beichuan fault; WFSD-3 drill hole and WFSD-3P drill hole are sited in the Guanxian-Anxian fault; WFSD-4 drill hole situated in the northern segment of Yingxiu-Beichuan fault. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

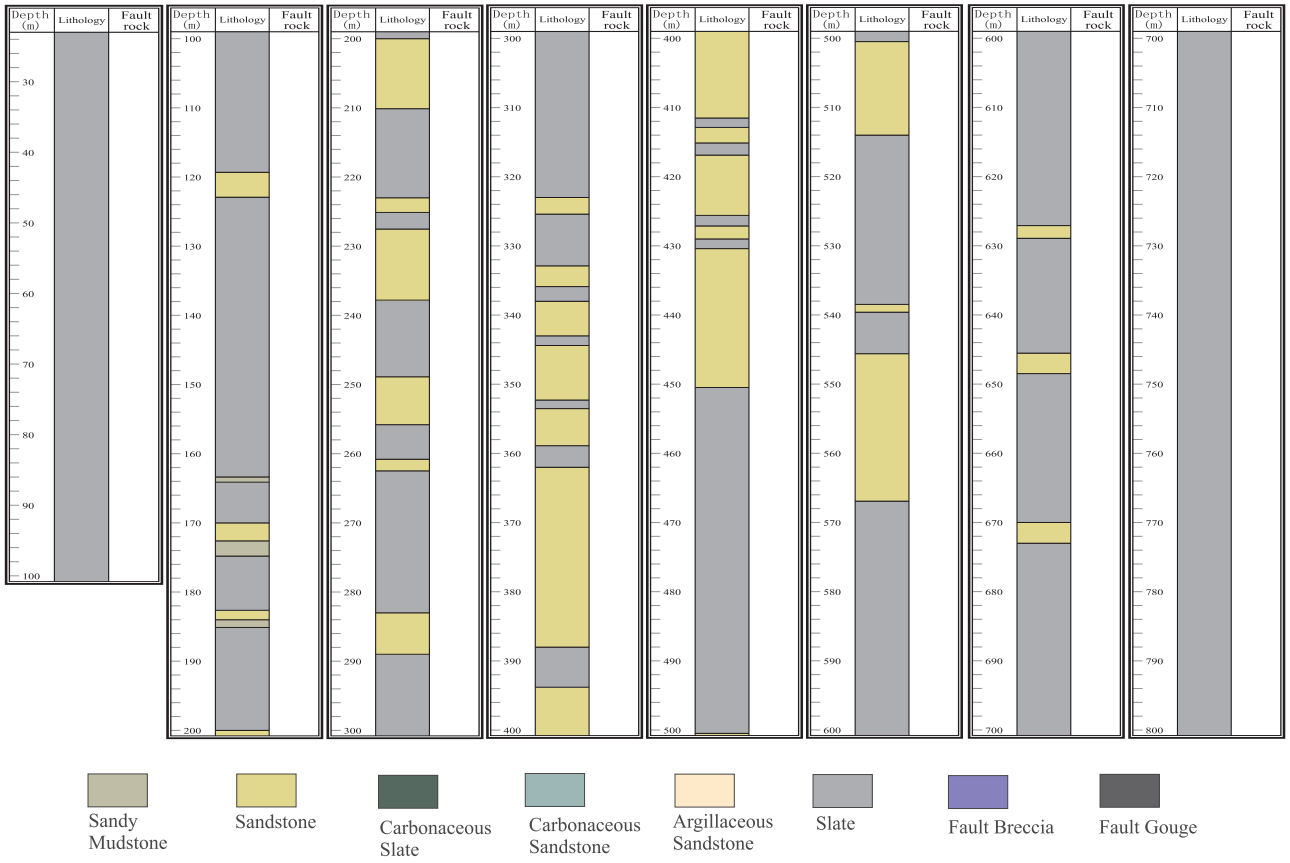

Fig. 2. Lithological profile (original rock) and fault rock distribution of the WFSD-4 cores, with depth being the well depth.

2015; Wu et al., 2008). Understanding the complex physics of earthquakes is among the major remaining unsolved problems in the geosciences (Tobin et al., 2007).

Fault rocks (Sibson, 1977) are important geologic rocks in earthquake science as they symbolize the only physical evidence for seismic activity. The laborious analysis of these rocks is essential to understanding the nature of earthquakes. Fault rocks record major episodes of fault movement, being one of the most significant subjects for understanding the fault zones nature as well as the whole history of fault motion (Sibson, 1977). Fault rocks have therefore been extensively investigated in earthquake studies (e.g. Solum et al., 2006; Song et al., 2007; Li et al., 2013, 2014, 2015; Si et al., 2014; Yang et al., 2013) to better comprehend their development and their physical and chemical properties. Despite the aforementioned existing research, so far, the SGR log signature has not yet been thoroughly exploited. Therefore, the WFSD drill hole offers a unique opportunity to characterize the Total Gamma Ray (GR), Potassium (K), Thorium (Th) and Uranium (U) log signature of fault rocks (and lithology). These radioactive logs resulting