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Concentration of Boron and Its Significance in the Qarain Clay Deposits, Riyadh Area, Saudi Arabia

Ahmed A. Almohandis
Department of Geology, College of Science, King Saud University
P.O. Box 2455, Riyadh 11451, Saudi Arabia

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Abstract. Boron concentrations in the Oarain clay deposits 230 km north west of Riyadh, Saudi Arabia, were quantitatively analyzed using spectrographic techniques. Boron concentrations in the 20 – 2μ fraction are higher with average value of 73 ppm boron than the average value of 41 ppm boron in the finest fraction. The size fraction 63 – 20μ has relatively higher boron contents than the size fraction 2μ. It is suggested that the high contents in the 20 – 2μ size fraction largely derived from the source rocks, and may indicate a non-marine origin for the Qarain clay deposits.

Introduction

The Qarain clay deposits occur in Qarain Town, about 230 km Northwest of Riyadh, the capital of Saudi Arabia. These clay deposits lie within the Marrat Formation (Fig. 1) which extends approximately between latitude 22° 50′ and 28° N as a part of the Lower and Middle Jurassic clastic and carbonate rock sequence. The whole sequence of the Marrat Formation does not crop out at one place, but is pieced together from several sections generally along latitude 25° 02′ N. Kaolinite is the dominant clay mineral in the Qarain clay samples, illite is minor compared with Kaolinite [1].

The purpose of this paper is to determine the boron concentration in the Qarain clay deposits, and to investigate if these deposits are of marine origin, deposited completely in saline water or deposited in a non-marine environment as suggested by the mineralogical and sedimentological works [1,2].

The mineralogical and sedimentological works on this area indicate that the clay minerals are authigenic in origin and have formed from the weathered products of the igneous and metamorphic rocks of the Arabian Shield. The prevalent kaolinite may

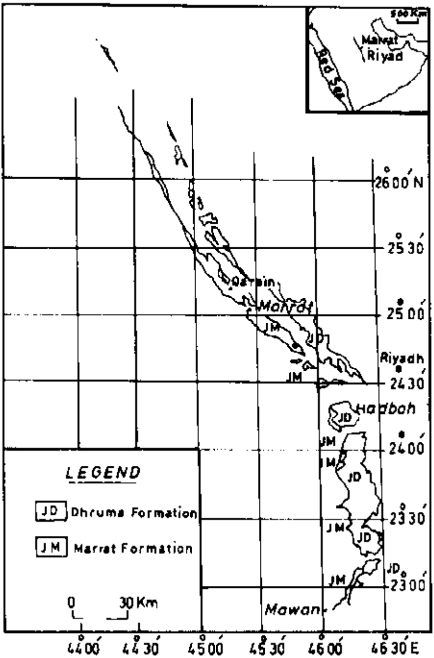

Fig. 1. Location map of the Qarain area and the extension of Marrat Formation, Saudi Arabia (After Assad [3]).

have formed from all source sediments when weathering solutions were acidic to neutral in flowing water (*i.e.* river) and leaching was sufficient to remove cations such as Fe, K, Mg, and Ca taken into solution. Moreover, the Lower Jurassic flora consists primarily of the form classopollis and associated trilete spores with rate marine microflora indicating probably a non-marine environment.

The Qarain clay deposits belong to the Marrat Formation. The Formation has been subdivided into three members based on lithology and faunal characteristics [3]. These members are: Hadbah member (Upper Marrat), Qarain member (Middle Marrat), and Shaqra member (Lower Marrat).

The Lower and Upper Marrat are mainly composed of carbonate rocks whereas the Middle Marrat is dominantly composed of argillaceous rocks and subordinate siltstone and silty sandstone. The Qarain member is made up of brownish red to dark-red mudstone, shale, sandy shale with occasional thin beds of calcareous sandstone. The thickness of the unit at the Qarain mesa is about 38 m.

The samples and lithologic description of the Qarain clay deposits at Khashm al Qarain is summarized in Fig. 2.

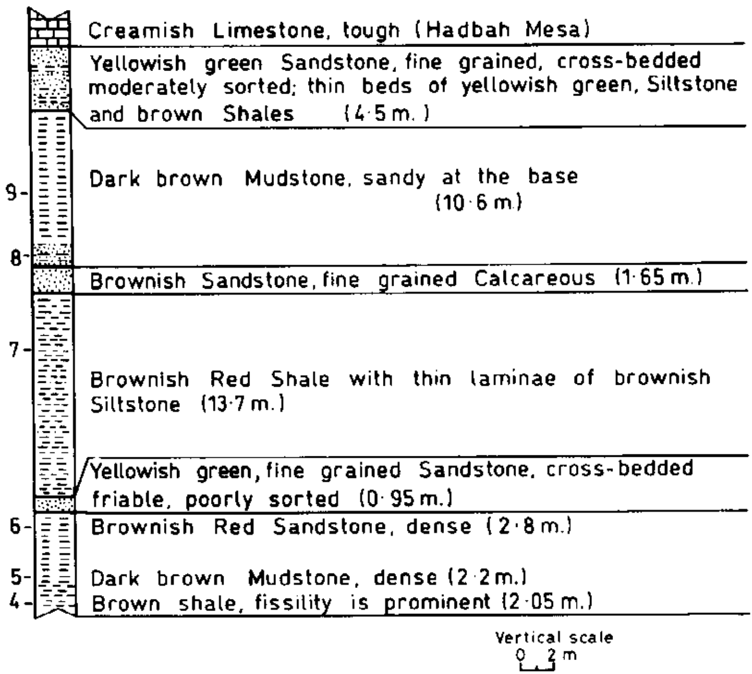

Fig. 2. Lithologic description of the Qarain clay deposits at Khashm Al Qarain.

Materials and Methods

Four representative samples were taken from the Qarain clay deposits for chemical analysis of the boron concentration. A few thin sections were studied in the coarser materials of clay deposits. The brownish sandstone (Fig. 2) are ferruginous quartzites [4]. Quartz grains are subangular to rounded and show cracks and small cavities filled with red pigments. A few grains of feldspar were seen under the microscope.

Each clay sample was classified into three size fractions. These size fractions are 63 – 20μ, 20–2μ and 2μ. The relationship between the grain size and settling time of these fractions for a 20 cm column at about 25°C is as follows:

grain size	h	min	sec
63 – 20μ	—	—	54
20 – 02μ	—	9	53
02μ	13	52	51

The size fractions of the four clay samples were quantitatively analyzed for boron concentrations using the spectrographic technqiue (Toronto, Canada). The determination of boron was based upon the use of B2497.73 Å with Be as internal standard, and is outlined in Curtis [5].

Results and Discussion

The use of boron as palaeoenvironmental indicator has been suggested by many workers. Frederickson and Reynolds [6], and Walker [7], have shown that boron tends to be concentrated in illite. Eugster and Wright [8], and Stubican and Roy [9] have shown the presence of boron in mica type structures. Harder [10], Tourtelet et al. [11], and Fleet [12], showed that the major clay minerals may incorporate boron but with different efficiency. Some workers such as Eager [13], Curtis [5], and Spears [14], indicate that boron can also be derived from the source rock and gained during deposition through absorption from organic matter. The boron content of marine shales is very much higher than that of freshwater shales and may be used as a criterion of origin [15].

Table 1 shows the boron concentrations in different size fractions. The table shows that boron is more concentrated in the 20 – 2μ fraction with an average value of 73 ppm B. compared with the average value of 41 ppm B in the finest fraction (2μ). The 63 – 20μ fraction mainly consists of kaolinite with traces of quartz, while the 2μ

fraction mainly consists of major kaolinite with some illite [1]. Moreover, the size fraction 63 – 20μ has relatively higher boron content than the size fraction 2μ.

Table 1 shows also that sample QA – 9 is diferent in its boron contents than the other three. Boron concentrations are low, and slightly similar in all three size fractions. This may indicate a cyclic variation in the boron contents within the Qarain clays similar to [16]. It is suggested that periodical fluctuations of ground-water influxes may occur at this stage of deposition.

Table 1. Boron concentration of the Qarain clays

Sample No.	Boron (in ppm) in different size fraction		
	63 – 20μ	20 – 2μ	2μ
QA – 4	72	75	43
QA – 5	76	82	44
QA – 7	56	84	41
QA – 9	44	50	37
Average B	62	73	41

If these clays were of marine origin (deposited completely in saline water), the 2μ size fraction would be expected to incorporate much more boron than the coarse 63 – 20μ size fraction. This is due to the presence of more illite in the 2μ fraction and the complete absence of this clay mineral in the 63 – 20μ fraction. The absorption of boron from saline water increases with the decrease of the grain size of the clay fraction [14].

The maximum boron content in the 20 – 2μ size fraction can be considered to be mainly derived from the source rocks and is associated largely with the kaolinite and illite. It is suggested that the boron concentrations in the Qarain clay deposits may indicate a non-marine origin for this type of deposit. The clay minerals in the Qarain area are authigenic in origin and have formed from weathered products of the Arabian Shield rocks through laterization or partial laterization of source rocks in a humid tropical region [17]. The boron is derived from basement rocks through laterization and could also be picked up from the country rocks by intruding granites as indicated by [18].

The formation of kaolinite as the dominant clay mineral in the Qarain clay deposits indicates that the parent material must be rich in alumina in the first place. From this parent rock most of the metal cations and an excess of H ions combined with efficient removal of silica in solution by associted Na and K ions is necessary [1].

It is believed that granitic bodies on the Arabian Shield were subjected to strong leaching to produce lateritic soils. These soils were then reworked and deposited in and around the Toarcian Sea [1,2].

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تركيز البورون ودلالته في رواسب صلصال القرائن، منطقة الرياض، المملكة العربية السعودية

أحمد عبدالقادر المهندس

قسم الجيولوجيا، كلية العلوم، جامعة الملك سعود، ص.ب ٢٤٥٥، الرياض ١١٤٥١، المملكة العربية السعودية

(استلم في ١٩ مايو ١٩٩١م؛ قبل للنشر في ٣ ديسمبر ١٩٩١م)

ملخص البحث. إن تركيز البورون لرواسب صلصال القرائن، حوالي ٢٣٠كم شمال غرب مدينة الرياض بالمملكة العربية السعودية قد حلل كميًا باستخدام التقنيات الطيفية (السبكتروغرافية).

وتكون تراكيز البورون في الجزء ذي الحجم ٢٠ ـ ٢ ميكرون عالية بقيمة متوسطة تبلغ ٢٣٧,٣ جزءًا في المليون من أكسيد البورون، بينما تكون القيمة المتوسطة ١٣٧,٥ في المليون من أكسيد البورون في الجزء الأدق والأكثر نعومة للرواسب. ويحتوي الجزء ذو الحجم ٦٣-٢٠ ميكرون على كميات أكبر نسبيًا من البورون عن الجزء ذي الحجم الذي يبلغ ٢ ميكرونًا.

ويمكن الاقتراح بأن الكميات العالية من البورون في الجزء ذي الحجم ٢٠ ـ ٢ ميكرونًا تكون مستمدة من الصخور المصدر، ويمكن أن يشير هذا إلى أصل غير بحري لرواسب صلصال القرائن.