



# 1st paleomagnetic investigation of Nubia Sandstone at Kalabsha, south Western Desert of Egypt



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## KEYWORDS

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**Abstract** Two profiles have been sampled from the Nubia Sandstone at Aswan, south Western Desert: the 1st profile has been taken from Abu Aggag Formation and the 2nd one was from Sabaya Formation (23.25°N, 32.75°E). 136 oriented cores (from 9 sites) have been sampled. Abu Aggag Formation is of Late Cretaceous (Turonian) and Sabaya Formation is of early Cretaceous (Albian–Cenomanian). The studied rocks are subjected to rock magnetic measurements as well as demagnetization treatment. It has been found that hematite is the main magnetic mineral in both formations. Four profile sections from Abu Aggag Formation, yielded a magnetic component with  $D = 352.7^\circ$ ,  $I = 36.6^\circ$  with  $\alpha_{95} = 5.2^\circ$  and the corresponding pole lies at Lat. = 82.8°N and Long. = 283.1°E. Five profile sections from Sabaya Formation, yielded a magnetic component with  $D = 348.6^\circ$ ,  $I = 33.3^\circ$  with  $\alpha_{95} = 5.8^\circ$  and the corresponding pole lies at Lat. = 78.3°N and Long. = 280.4°E. The obtained paleopole for the two formations lies at Lat. = 80.5°N and Long. = 281.7°E. The obtained magnetic components are considered primary and the corresponding paleopole reflects the age of Nubia Sandstone when compared with the previously obtained Cretaceous poles for Egypt.

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## 1. Introduction

The term Nubia Sandstone as proposed by Russegger (1834) has been defined by “the sequence of clastic sediments rests over the hard basement rocks and covered by the upper

Cretaceous phosphate beds in Southern Egypt”. According to Klitzsch and Lejal-Nicol (1984), Klitzsch and Schrank (1987) and Klitzsch and Wycisk (1987); Sabaya Formation and Abu Aggag FM are members of Nubia Sandstone formations at Aswan area.

### 1.1. Abu Aggag Formation

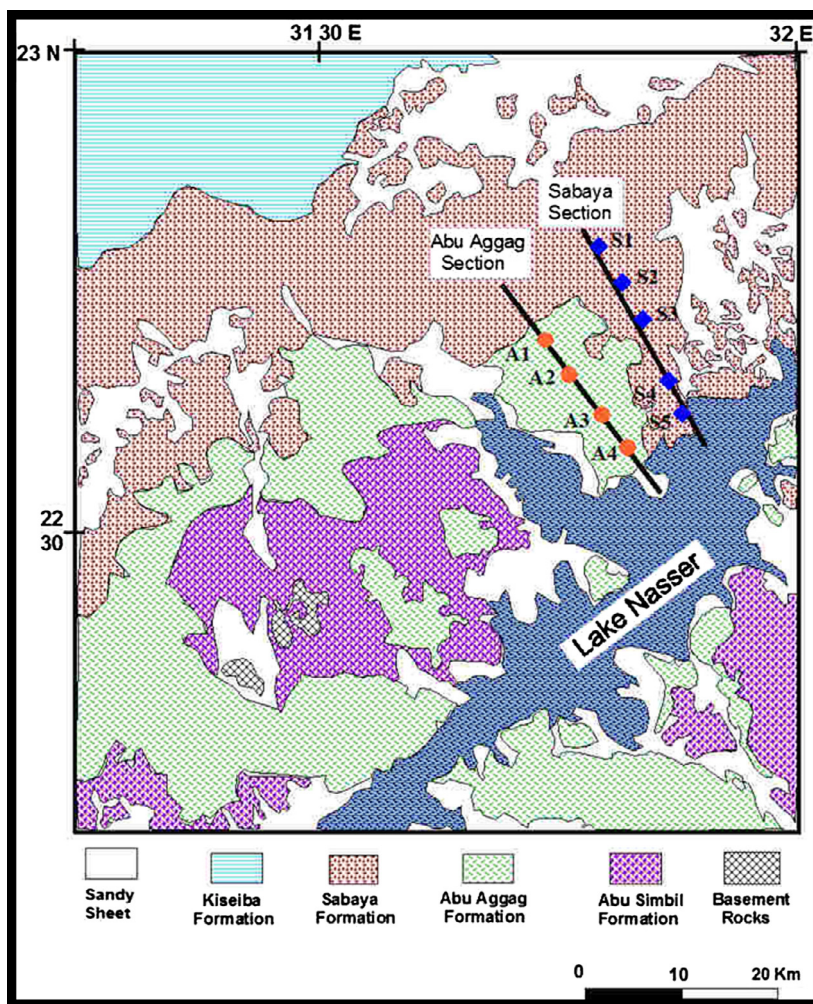
Abu Aggag Formation overlies basement in the area between Qena and Abu Simbel, and is overlain by Timsah Formation. Basal conglomerates fill the irregular topography of the basement and grade upward into coarse-grained, cross-bedded sandstones with terapod trackways. The uppermost part of

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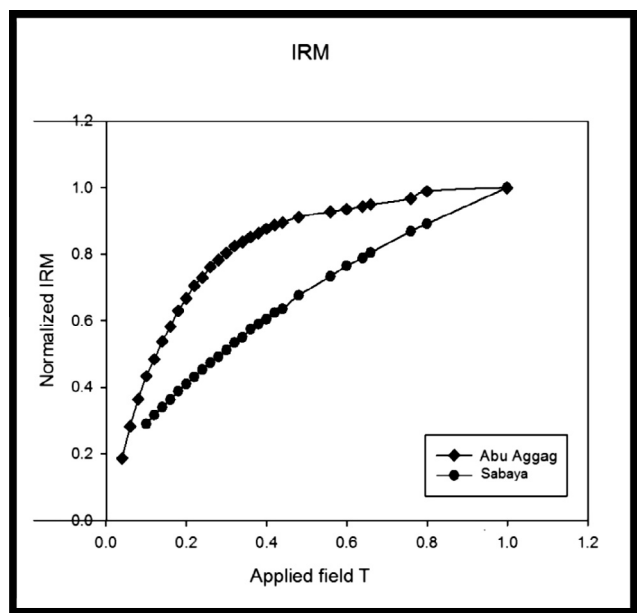
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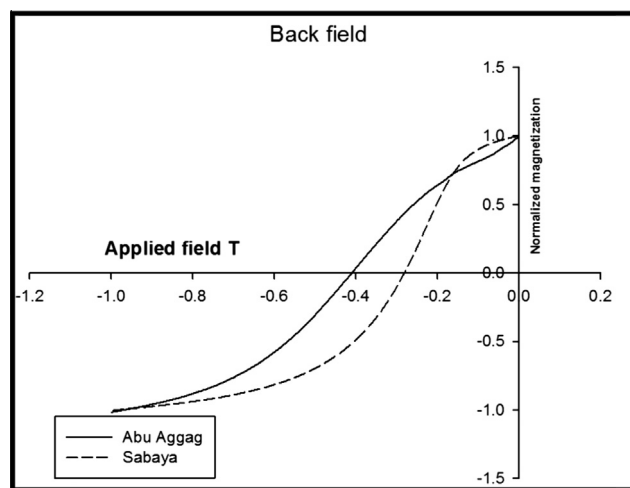
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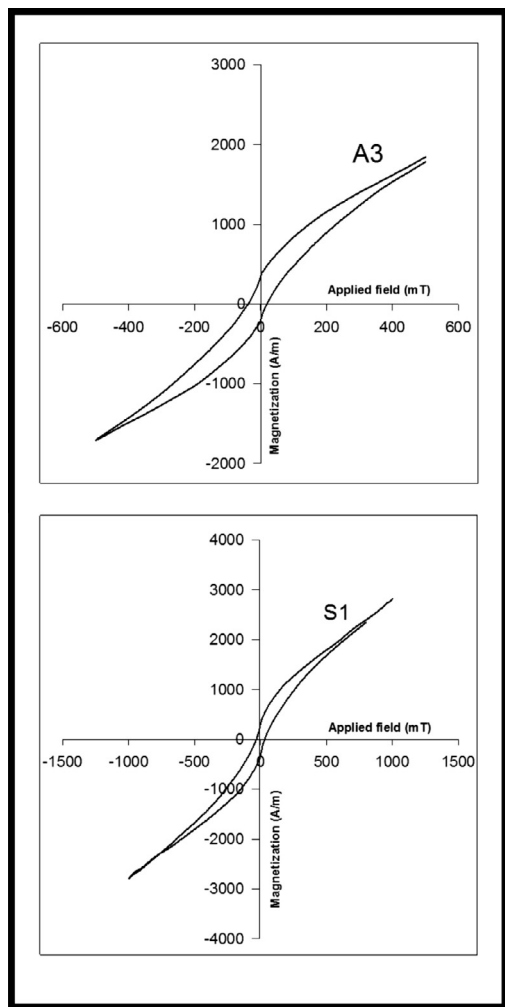
**Figure 1** Location map of the study area with the sampling sites, the red circles from A1 to A4 represent the sampling sites of Abu Aggag Formation and the blue squares from S1 to S5 represent the sampling sites of Sabaya Formation.



**Figure 2** IRM curves for representative specimens from Abu Aggag and Sabaya Formations.



**Figure 3** Back field curves for representative specimens from Abu Aggag and Sabaya Formations.



**Figure 4** Hysteresis loop curves for representative specimens from Abu Aggag (A3) and Sabaya (S1) formations.

the Abu agag Formation consists of paleosols and channel sandstones. The Formation was assigned to Turonian age by El-Naggar (1970).

1.2. Sabaya Formation

Sabaya Formation overlies Abu Ballas Formation and follows the Albian regression. The type locality of this formation is at Qulu El-Sabaya hills on the Kharga-Dakhla road. It is made up of a sequence of clearly fluvial sediments which start at the base with an erosional surface overlain by a 30 m thick white kaolinitic paleosol sandstone rich in root remains.

Sabaya Formation is most likely of Albian to early Cenomanian age. A sample investigated by Schrank (1987) from the top of the correlative unit in Ammonite Well-1 yielded a microflora of late Albian–Cenomanian age. Between the continental Sabaya Formation and the following transgressive Maghrabi Formation, there is a gap in sedimentation and formation of topographic relief (Bisewsk, 1982).

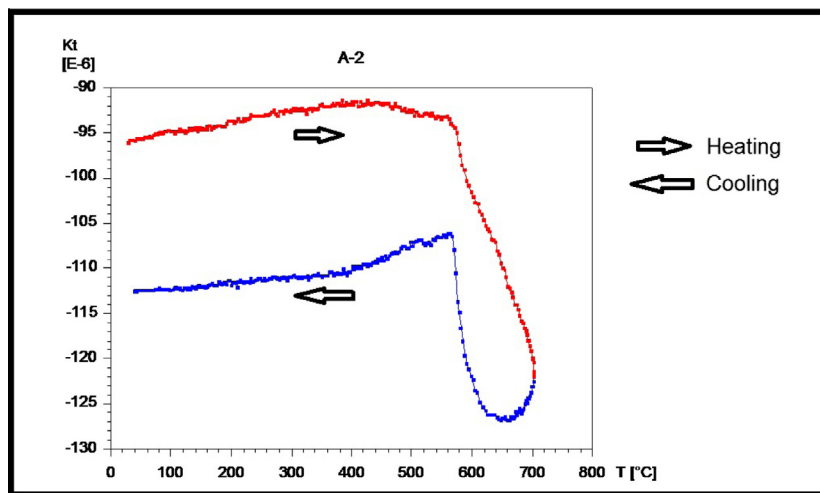
The purpose of this study is to investigate the magnetization carried by these rocks and to use the paleomagnetism in dating its magnetization. It will be valuable, on the light of the obtained results, to try understanding the post depositional processes that may have influenced the magnetization of these formations.

2. Sampling

In the present study 136 oriented core samples have been collected from 9 sites covering Abu Aggag and Sabaya formations in Aswan area at the West of Nasser Lake (Fig. 1). The core samples were cut into 265 standard sized specimens in the Paleomagnetic Lab. of the National Research Institute of Astronomy and Geophysics, Helwan, Egypt.

3. Rock magnetic measurements

Several rock magnetic experiments have been carried out to identify the magnetic mineral(s) within the collected samples. The performed rock magnetic experiments are; susceptibility vs. temperature curves, using KLY-KAPPABRIDGES of AGICO, Isothermal Remanent Magnetization (IRM) acquisition curves, using the Vibrating Sample Magnetometer; (VSM), coercivity of remanence (Back-field curves) using the VSM and Hysteresis Loops (using the VSM and MicroMag).



**Figure 5** Susceptibility vs. temperature curves for Abu Aggag Formation.

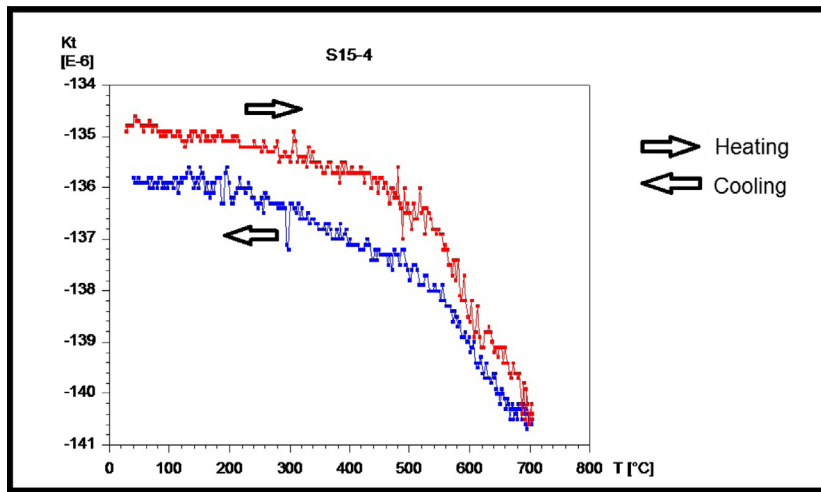


Figure 6 Susceptibility vs. temperature curves for Sabaya Formation.

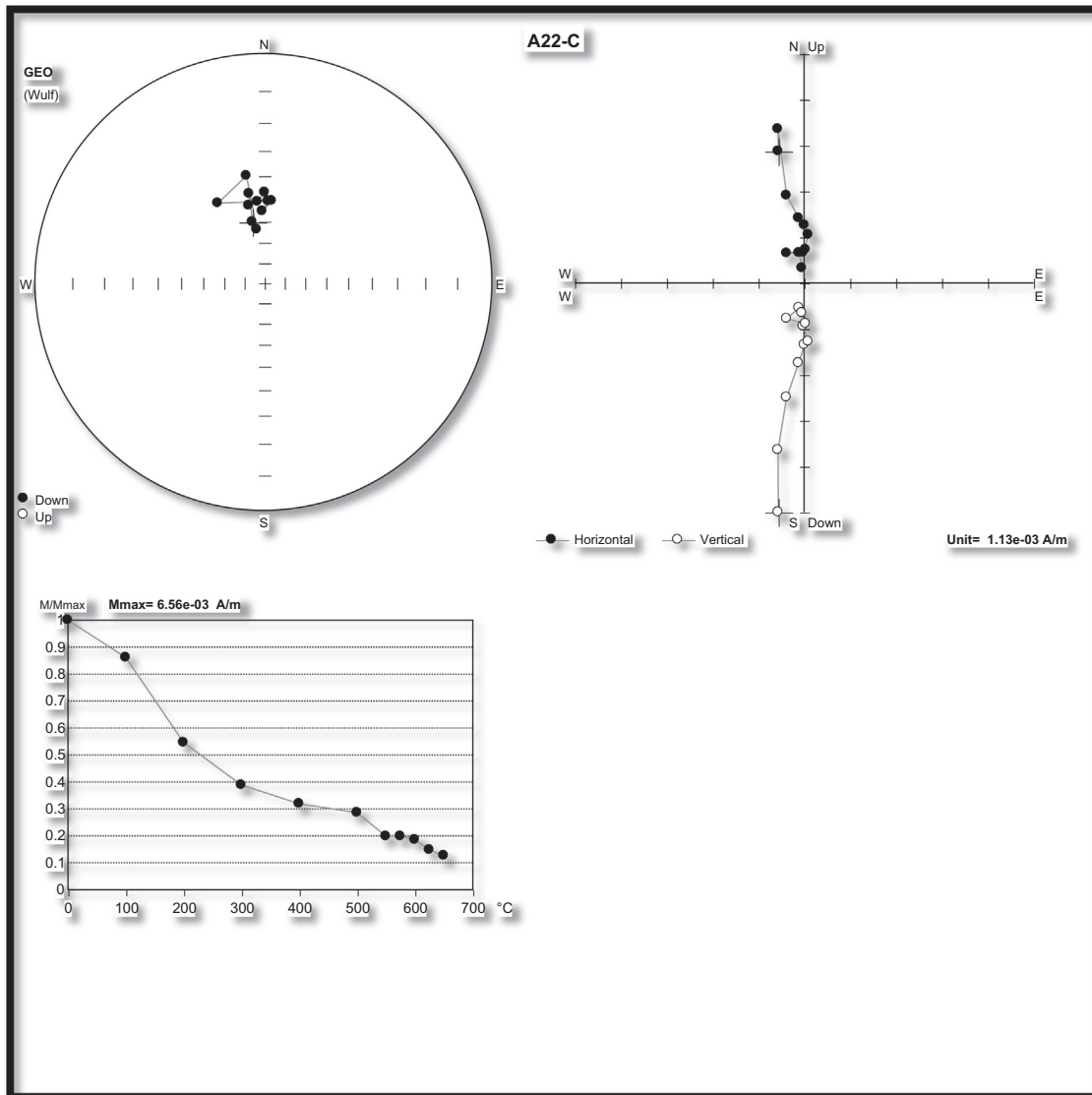
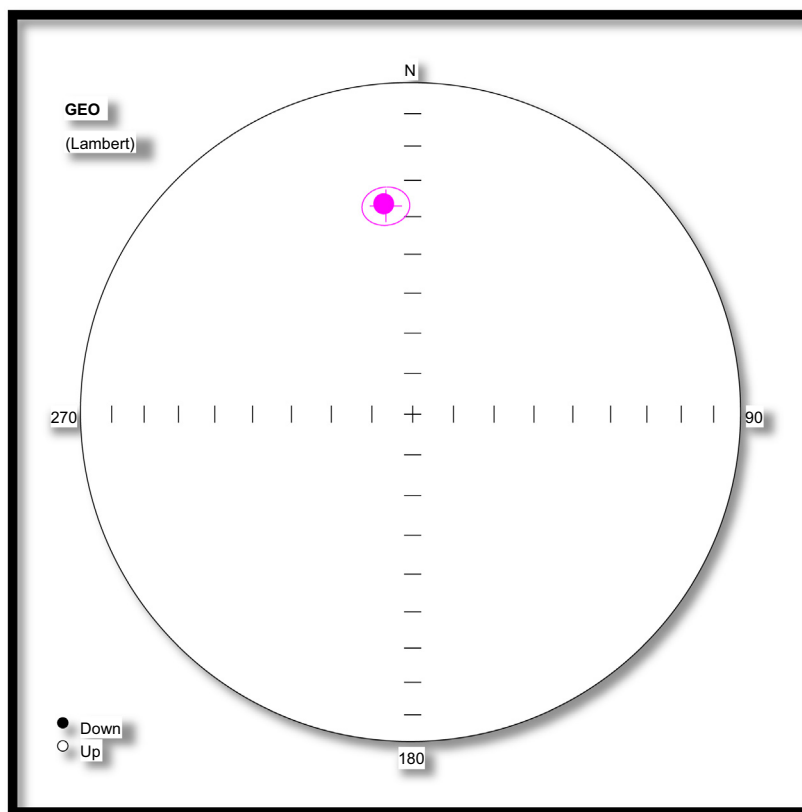


Figure 7 Thermal demagnetization plots [Stereonet, Zijderveld diagram (Zijderveld, 1967) and intensity decay curve] for a representative specimen from Abu Aggag Formation.



**Figure 8** Stereographic projection of site mean direction for Abu Aggag Formation.

**Table 1** Demagnetization results of Abu Aggag Formation.

Site No.	$N$	$D$ (°)	$I$ (°)	$\alpha_{95}$ (°)	$K$	VGP	
						P_Lat. (°N)	P_Long. (°E)
A1	14	355.9	37.8	9.0	56	85.8	278.8
A2	17	347	39.7	10.6	33.63	78	303
A3	14	1.8	31.2	8.3	52	83.7	196.3
A4	12	345.8	33.3	20.7	53	75.9	285.3
Mean (A)	57	352.7	36.6	5.2	47.33	82.8	283.1

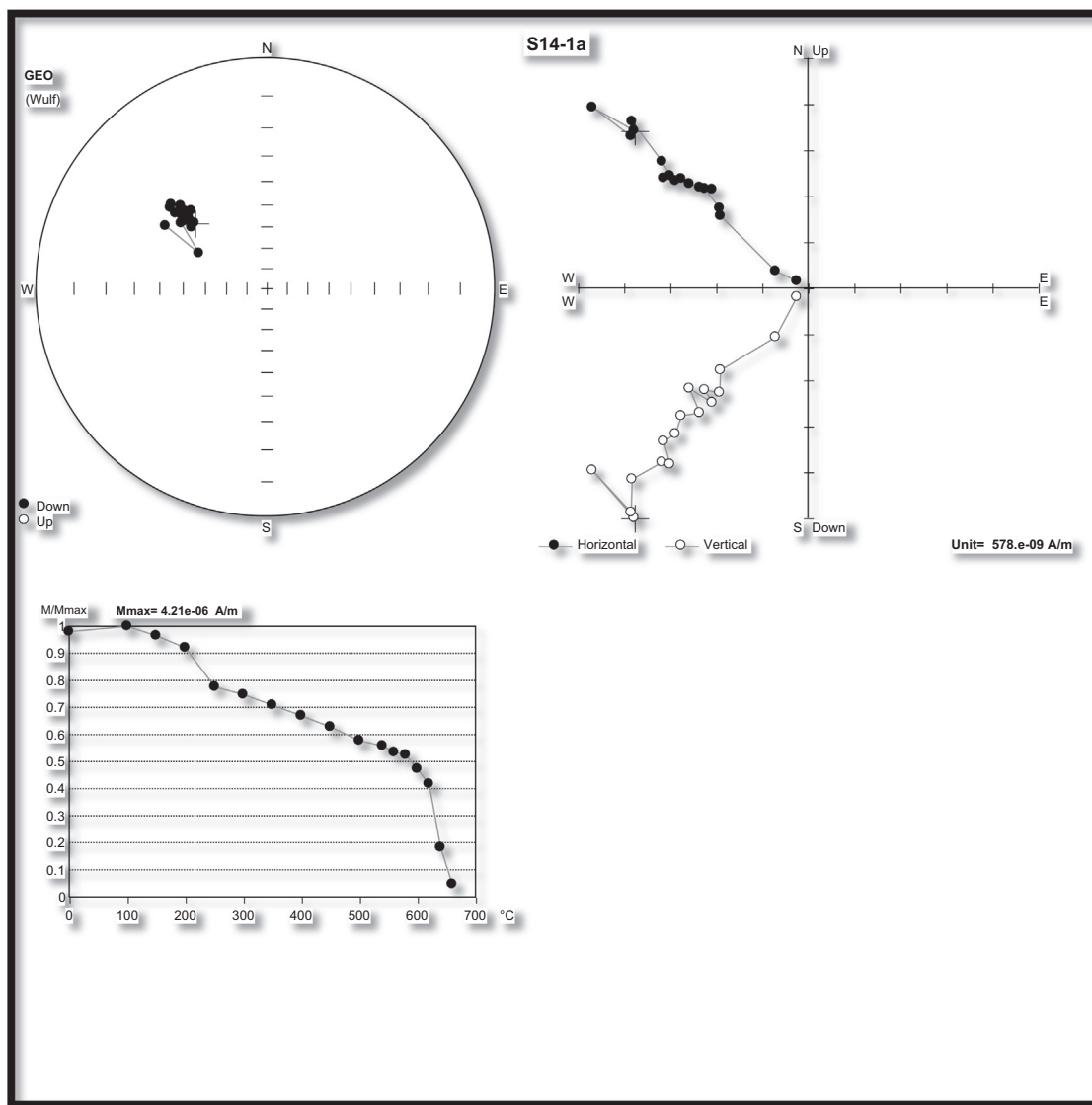
Key:  $N$ : number of specimens (sites in mean) exhibit the specific component,  $D$ : declination,  $I$ : inclination,  $\alpha_{95}$ : radius of 95% circle of confidence (Fisher, 1953) for mean direction,  $K$ : precision parameter (Fisher, 1953), P\_Lat., P\_long.: latitude and longitude of the Virtual Geomagnetic Pole.

**Table 2** Demagnetization results of Sabaya Formation.

Site No.	$N$	$D$ (°)	$I$ (°)	$\alpha_{95}$ (°)	$K$	VGP	
						P_Lat. (°N)	P_Long. (°E)
S1	14	346.3	37.8	23	16.86	77.2	297.1
S2	19	341.3	23.2	11.1	22.62	69.2	274.1
S3	15	349	29.1	15.9	24	77.3	268.8
S4	13	350	36.1	9.9	18.67	80.3	286.9
S5	14	7.2	45.9	14.1	43.21	82.1	86.7
Mean (S)	75	348.6	33.3	5.8	18.43	78.3	280.4

Key: See Table 1.





**Figure 9** Thermal demagnetization plots for a representative specimen from Sabaya Formation (normal polarity).

The isothermal remanent magnetization (IRM) acquisition curve is constructed for several specimens representing all sampled sites. Fig. 2 represents an example of the constructed IRM curves for the studied formations. The constructed curves show that the studied specimens did not reach the saturation state until 1000 mT, revealing the presence of hard magnetic mineral(s).

Back field curves constructed for the same specimens show that the existed magnetic mineral is of high coercivity values, ranging in general from 290 to 410 mT (Fig. 3). This hard magnetic mineral of high coercivity could be hematite and/or goethite. Hysteresis loop curves in Fig. 4 show that no saturation state was reached indicating the presence of hematite as the main magnetic carrier.

The obtained thermomagnetic curves (Figs. 5 and 6) reveal that the Curie temperature of the existed magnetic mineral ranges in value from 620 to 680 °C. Such high values of coercivity and Curie temperature characterize the hematite mineral. This mineral could carry a stable magnetization within the investigated specimens.

#### 4. Paleomagnetic measurements

Both thermal and alternating field (AF) demagnetization have been applied on studied specimens. Thermal demagnetization has been done using non-magnetic thermal demagnetizer of Magnetic Measurements (MMTD80). In addition, AF demagnetization has been carried (within a magnetically shielded room) using the Degausser attached with the 2-G SQUID at the Paleomagnetic Lab., Poland. The magnetic remanence of the specimens has been measured using Cryogenic Magnetometer.

The AF demagnetization was not effective as hematite is the main magnetic mineral in most specimens.

Analysis of the demagnetization data has been done, using the Remasoft 3.0 computer program, to separate the characteristic magnetic components carried by each specimen. After getting the mean direction of each site and the site means, the mean of the corresponding Virtual Geomagnetic Poles (VGPs) has been calculated using Fisher statistics (Fisher,

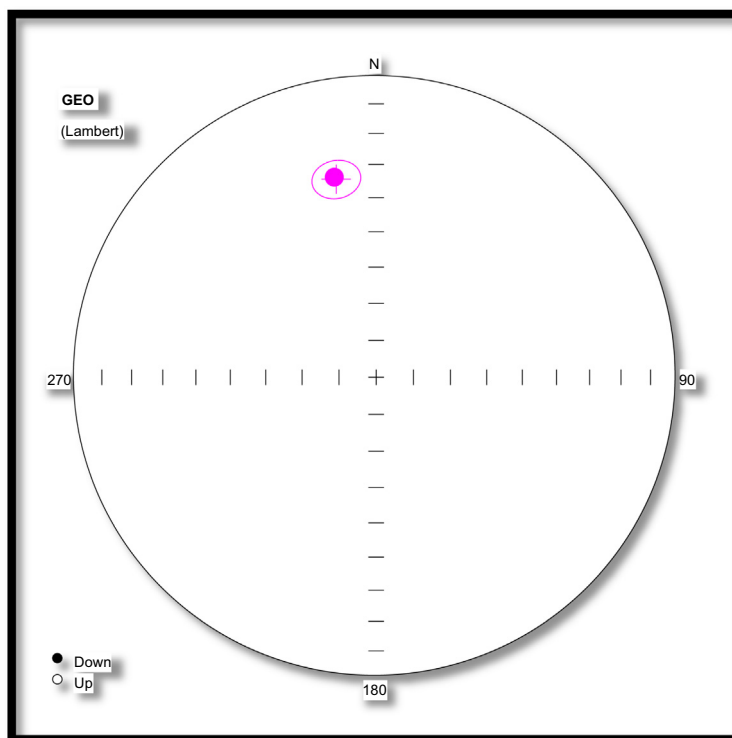


Figure 10 Stereographic projection of the Sabaya Formation site mean.

1953), representing the paleomagnetic pole position for the studied formations.

4.1. Abu Aggag Formation

As expected when studying sedimentary rocks; the intensities of remanence were relatively low ranging from  $3 \times 10^{-3}$  to  $2.3 \times 10^{-3}$  A/m. The susceptibility values of the studied specimens are very low, ranging from  $-3 \times 10^{-6}$  to  $18 \times 10^{-6}$  SI units.

Example of thermal demagnetization data for a representative specimen from Abu Aggag Formation is shown in Fig. 7. This example shows the presence of a stable single magnetic component of high Curie temperature ( $> 600$  °C).

Magnetic components isolated from Abu Aggag Formation show normal polarity (Fig. 8). The obtained mean direction is Dec. =  $352.7^\circ$ , Inc. =  $36.6^\circ$ , and  $\alpha_{95} = 5.2^\circ$  and the corresponding paleopole lies at Lat. =  $82.8^\circ$ N and Long. =  $283.1^\circ$ E (Table 1).

4.2. Sabaya Formation

Demagnetization process reveals low intensity values of NRM, ranging from  $48 \times 10^{-3}$  to  $3.3 \times 10^{-3}$  A/m. Also the values of the magnetic susceptibility of these specimens are very low, ranges between  $-2 \times 10^{-6}$  and  $9 \times 10^{-6}$  SI units.

A stable single component carried by hematite has been isolated by demagnetization. A gradual decrease in magnetization – till  $675$  °C – is obviously shown in Fig. 9 with stable direction. This indicates that this magnetization is carried by coarse grain hematite.

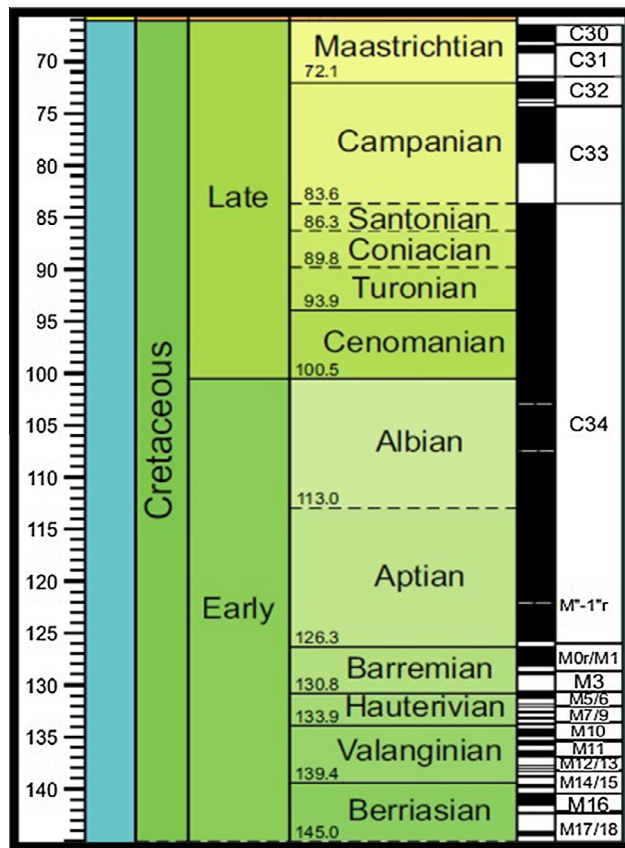
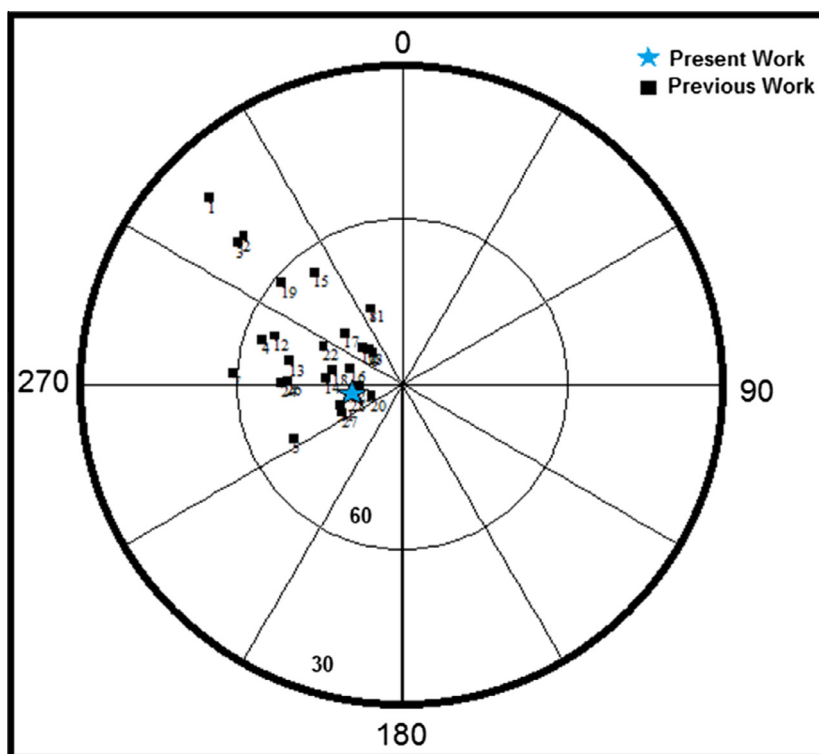


Figure 11 Modified after Geologic Time Scale (Gradstein et al., 2012).

**Table 3** Selected Cretaceous paleomagnetic poles of Egypt with the pole of present work.

No	Rock unit, locations	Age Ma	Lat (°N)	Long (°E)	References
1	Ekma chalk, Sinai, Egypt	66–98	40	226	Kafafy and Abdeldayem (1995)
2	Qabaliat S.S. Sinai, Egypt	91–97	50	227	Kafafy and Abdeldayem (1995)
3	NazzazatTronian, Sinai, Egypt	88–90	50	229	Kafafy and Abdeldayem (1995)
4	QusierTrachytes, Egypt	63–92	63	252	Ressetar et al. (1981)
5	East El Owienat volcanic, Egypt	65–97	68	296	Hussain and Aziz (1983)
6	El Kahfa Ring complex Egypt	74–85	61-	238	Abd El-All and Shreef (1988)
7	Abu khrug Ring complex, Egypt	87–91	59	266	Ressetar et al. (1981)
8	E. Aswan Nubian SS, Egypt	45–135	75	203	El Shazly and Krs (1973)
9	WadiNatash Nubian S.S, Egypt	45–135	82	223	Schult et al. (1978, 1981)
10	Aswan N.S.S., Egypt	Cretaceous	80	227	Schult et al. (1978)
11	Aswan Iron & sandstone, Eyp	Cretaceous	75	2.03	El Shazly and Krs (1973)
12	Abu Khruqe-El kahfa intrusion, Egypt	72–98	65	249	Ressetar et al. (1981)
13	WadiNatash Volcanic, Egypt	86–100	69	258	Schult et al. (1981)
14	Qena, N.S.S., Egypt	70–145	76	265	Hussain et al. (1976)
15	WadiNatash S.S & volcanic, Egypt	78–111	64	218	El Shazly and Krs (1973)
16	Idfu-MarsaAlam N.S.S, Egypt	Cretaceous	80	252	Schult et al. (1978)
17	WadiNatash Intrusion, Egypt	78–111	76	228	Ressetar et al. (1981)
18	East Owienat N.S.S, Egypt	Cretaceous	77	258	Hussain and Aziz (1983)
19	Abu Rawash sediments,	~80	61	230	Kafafy et al. (1994)
20	N.S.S. G El Minisherah, Egypt	Cretaceous	84	288	Ibrahim (1993)
21	N.S.S. G. ElHalal, Egypt	Cretaceous	78	288	Ibrahim (1993)
22	N.S.S. Central Eastern Desert, Egypt	Cretaceous	74	244	El-Hemaly et al. (2004)
23	Gifata Sediments, Egypt	Cretaceous	81	224	Sardeth et al. (1989)
24	East El Oweinatsyenite, Egypt	Cretaceous	68	269	Hussain and Aziz (1983)
25	Phosphate and sandstone at Gabel Gifata, Egypt	66–75	82	271	Abd El-All (1996)
26	El-Naga Ring Complex, Egypt	~140	69	268	Abd El-All (2004)
27	Nubia S.S. W. Desert, Egypt	113–124	78	294	El-Shayeb et al. (2013)
28	Nubia S.S. Aswan, Egypt	89–113	80.5	281.7	Present work

**Figure 12** Previous obtained Cretaceous poles of Egypt with the pole of the present study.



The components isolated from this formation show normal polarity (Fig. 10). The mean direction obtained for Sabaya Formation is, Dec. = 348.6°, Inc. = 33.3°, and  $\alpha_{95} = 5.8^\circ$ , with corresponding paleopole lies at Lat. = 78.3°N and Long. = 280.4°E (Table 2).

## 5. Discussion and conclusion

In this study, paleomagnetic characteristics of Nubia Sandstone at Kalabsha area near Aswan (23.25°N, 32.75°E) have been dealt with. 9 sites comprising 136 oriented core samples along two profiles from Abu Aggag and Sabaya Formations of Cretaceous age were used.

Rock magnetic measurements indicated that hematite is the principal magnetic carrier in most of specimens. Traces of magnetite were also recorded in some specimens.

Thermal demagnetization was found to be more effective than AF demagnetization and helped much in the isolation of the magnetic components. Apart from few recent components, most specimens yielded primary magnetic components that may reflect the age of the Nubian Sandstone. Isolated component from Abu Aggag Formation show normal polarity proving its primary origin as the Turonian age on the polarity time scale (Fig. 11) is of normal polarity. The normal polarity component of Sabaya Formation agrees with the polarity of Albian–Cenomanian age on the polarity time scale (Fig. 11) indicating the primary origin of such polarity. The paleopole calculated for the two formations lies at Lat. 80.5°N and Long. 281.7°E fell close and within the certainty acceptable limits when compared to selected reference Cretaceous poles from Egypt (Table 3 and Fig. 12).

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