

Comments on: “New age of the lower part of the Kuhlan Formation, Northwest Yemen” by M.H. Stephenson and S.Z.A.K. Al-Mashaikie (GeoArabia, 2010, v. 15, no. 2, p. 161-170)

Mohammed Al-Wosabi

Stephenson and Al-Mashaikie (2010) suggest new ages for the lower part of Kuhlan Formation and underlying Akbarah Formation (see Table). Their paper is based on only two samples taken from the Kuhlan Formation and does not consider other possible lines of evidence given in previous studies. To begin with I would like to correct what appear to be several errors.

- (1) The preferred spelling of the glaciogenic rock unit in Yemen is “Akbarah” rather than “Akbra”.
- (2) On page 161 the paper incorrectly credits Carpentier and Lamare (1932) for introducing the Kuhlan Series rather than Lamare (1930).
- (3) The paper cites Diggins et al. (1988) as assigning a Late Triassic to Early Jurassic age for the upper beds of the Kuhlan Formation. On macrofossil evidence Diggins et al. assigned an Early – Middle Jurassic age for the upper part, and an Early Jurassic or even Triassic for the base of the formation.
- (4) The correlation of the Kuhlan Formation to PDO biozones is inconsistently reported in the paper; in the abstract and Figure 4 to Biozones 2165A to 2141A (Late Carboniferous – Early Permian), but in the conclusion to upper 2165B to lower 2141A biozones (Late Carboniferous).
- (5) Figure 4 shows the Unayzah B of Saudi Arabia as Late Carboniferous – Early Permian, whereas it was dated Early Permian (Asselian – Sakmarian) by Stephenson et al. (2003), as shown in Melvin and Sprague (2006) and Garming et al. (2010) and as Sakmarian in Al-Husseni (2006).
- (6) Whereas El-Nakhal et al. (2002) and Al-Mashaikie (2002) assigned a Late Carboniferous – Early Permian age to the Akbarah Formation, this paper considers it as probably Late Carboniferous, but does not provide an explanation for the age change.

Next, although the paper is focused on palynology, the reader would have benefited from a more comprehensive description of the lithological column. For example, Plate 1 shows several field photos but these do not represent the range of lithofacies as stated on p. 161.

Rock unit	Carpentier and Lamare (1932)	Kruck and Thiele (1983)	El-Nakhal (1987, 1992, 1994) and et al. (2002)	Hunt Oil Company (1987, 1989)	Diggins et al. (1988)	Al-Mashaikie (2002)	Stephenson and Al-Mashaikie (2010)
Kuhlan Formation	Lias	---	Lias (after Carpentier and Lamare, 1932)	No older than Oxfordian	Early – Middle Jurassic and no older than Oxfordian	---	Late Carboniferous
Akbarah Formation	---	Permian – possibly Early Permian	Late Carboniferous – Early Permian	---	Early Permian	Carboniferous – Permian	Late Carboniferous
Comments	“Plant debris”	Same area as “Paper” “Pollen grains”	Nearly same area of “Paper” “Pollen grains”	Subsurface of Marib Al-Jawf Basin “Pollen grains”	Same area as “Paper” “macrofossil” and subsurface of Marib Al-Jawf Basin “Pollen grains”	Study area larger than “Paper”	“Pollen grains”

Figure 1: Different ages given to Kuhlan and Akbarah Formations by different authors.

The significance of the contact between the Akbarah and Kuhlan formations is important to discuss in this paper. According to Kruck and Thiele (1983), El-Nakhal (1987, 1992) and Al-Mashaikie (2002, p. 23) the Akbarah/Kuhlan boundary is unconformable in all studied sections. Any stratigraphic discontinuity, particularly an unconformity, is a time gap. The paper, however, does not discuss the duration of this gap nor does it show it in figure 4.

Finally, to determine the age of a rock unit requires a sufficient number of samples to statistically represent the entire stratigraphic column under consideration. The paper fails to meet this requirement with only two samples whose localities are not fully documented, thus leading to possible misinterpretation of age assignments.

REFERENCES

- Al-Husseini, M.I. 2006. Permian Arabian tectono-stratigraphy chart. *GeoArabia*, v. 11, no. 4, p. 95-102.
- Al-Mashaikie, S.Z.A. 2002. Stratigraphy, geochemistry and basin analysis of the Akbarah Formation in the Republic of Yemen. Unpublished PhD Thesis, Sana'a University, Yemen, 303 p.
- Carpentier, C.A and P. Lamare 1932. Vegetaux fossiles du Yemen. *Bulletin de la Societe Geologique de France*, 2, p. 83-92.
- Diggens, J., R. Dixon, R. Dowin, J. Harris, M. Jakubowski, S. Mathews, D. Southwood and P. Ventris 1988. A geological model for the evolution of the Ma'rib-Jawf Basin, Yemen Arab Republic. Robertson Research International Limited and Hunt Oil Company. Unpublished Report no. 2616/IIb.
- El-Nakhal, H.A. 1987. A lithostratigraphic subdivision of Kuhlan Group in Yemen Arab Republic. *Iraqi Journal of Science*, v. 28, p. 149-180.
- El-Nakhal, H.A. 1992. Contribution to the knowledge of the Late Paleozoic glaciation in the Republic of Yemen. *Journal of King Saud University*, v. 4, Science (2), p. 193-204.
- El-Nakhal, H.A., M.H. Stephenson and B. Owens 2002. New Late Carboniferous – Early Permian palynological data from glacial sediments in the Kooli Formation, Republic of Yemen. *Micropaleontology*, v. 48, p. 222-228.
- Garming, J.F.L., G.F. Franks, H. Cremer and A.A. Abbink 2010. Biogenic silica microfossils in sediments of the Permian – Carboniferous Unayzah Formation, Saudi Arabia. *GeoArabia*, v. 15, no. 1, p. 119-132.
- Hunt Oil Company 1987. Confidential report no. 3671/Ib.
- Hunt Oil Company 1987. Confidential report no. 6624/Id.
- Hunt Oil Company 1989. Confidential report no. C1/288.
- Hunt Oil Company 1989. Confidential report no. 6626/Id.
- Kruck, W. and J. Thiele 1983. Late Palaeozoic glacial deposits in the Yemen Arab Republic. *Geologisches Jahrbuch Reihe B: Regionale Geologie Ausland*, v. 46, p. 3-29.
- Lamare, P. 1930. Nature et extension des depots secondaires dans L'Arabie, l'Ethiopie et les pays Somalia. *Mémoires de la Société géologique de France*, n.s. 6, fasc. 3-4, 14, p. 49-68.
- Melvin, J. and R.A. Sprague 2006. Advances in Arabian stratigraphy: Origin and stratigraphic architecture of glaciogenic sediments in Permian – Carboniferous lower Unayzah sandstone, eastern central Saudi Arabia. *GeoArabia*, v. 11 no. 4, p. 105-152.
- Stephenson, M.H. and S.Z.A.K. Al-Mashaikie 2010. New age of the lower part of the Kuhlan Formation, northwest Yemen. *GeoArabia*, v. 15, no. 2, p. 161-170.

REPLY TO COMMENTS BY M. AL-WOSABI

Michael H. Stephenson and Sa'ad Zeki A. Kader Al-Mashaikie

Firstly we would like to thank Al-Wosabi for his comments on the paper and are pleased that our work is stimulating debate. We will consider his comments in order.

It seems that a number of errors have indeed crept into the text, which is very unfortunate, however these are very peripheral and do not alter the findings of the paper in any way. The assemblages recovered from the lower part of the Kuhlan Formation are the best preserved that the first author (MHS) has so far seen and the date that is suggested is considered to be very robust.

We agree that Akbarah is the correct name for the formation below the Kuhlan. The name Akbra was inadvertently used because of its association with the Wade Akbra, where the formation crops out.

There seems to be some confusion as to the origin of the term 'Série de Kohlan' or as it seems also to be known 'Série de Kholan'. As Beydoun et al. (1998) refers, the lower beds of the Kuhlan Formation were included by Lamare as well as Carpentier and Lamare in the 'Série de Kohlan' (sometimes Kholan, sic.). We would welcome clarification.

In regard to the unpublished report by Diggens et al. (1988) in which we stated that the upper beds were Late Triassic to Early Jurassic, this does appear to be incorrect and arose from confusion between the first and second authors.

Over the age of the lower 60 m of the Kuhlan Formation there is no doubt however. The age is not reported inconsistently. In the abstract the age was reported as PDO Zone 2165A to 2141A and this is precisely how it is shown in Figure 4. In the conclusions the most precise possible range is given (upper 2165B to lower 2141A) because of the co-occurrence of the taxa *D. tentus* and *S. triangulus* which only occur together between upper 2165B and lower 2141A in South Oman (for details see Penney et al., 2008).

As regards the chronostratigraphic age of the lower 60 m of the Kuhlan Formation, Al-Wosabi mentions that our paper does not 'provide an explanation for the age change' referring to the fact that the ages of 2165A to 2141A have been revised lower. This is not true. The paper clearly states on page 165-167 that 'Recent work on radiometrically-dated sequences in Namibia (Stephenson, 2009) has shown that the range of *Converrucosporites confluens* and the eponymous biozone probably extends lower than previously thought and therefore the 2165A to 2141A biozones (see Penney et al., 2008) may be slightly older than suggested by Penney et al. (2008)'.

At the time of the writing of the paper it was not thought that a full explanation of the recalibration was necessary, but a short explanation is given here for further clarity and to stimulate debate. For fuller details the reader is directed to Stephenson (2009).

In essence much chronostratigraphic dating of Gondwana glaciogenic and postglacial sequences depends on the *Converrucosporites confluens* Opper Zone established in the Canning Basin, Australia (see Stephenson, 2008). The biozone is important because it was directly associated with a marine fauna that suggested a correlation with the standard Russian Lower Permian stages, and because the eponymous species has a wide occurrence in Gondwana outside Australia, e.g. Antarctica, Argentina, Brazil, India, Oman, Saudi Arabia and Uruguay. The zone was an advance because for the first time a standard Russian Lower Permian stage name could be given to a Gondwana sequence, originally mid-to late Asselian. This age was later revised to latest Asselian to Early Sakmarian. However Stephenson (2009) showed that the *Converrucosporites confluens* Opper Zone is associated with a radiometric date of 302.0 ± 3.0 Ma (Pennsylvanian; Gzhelian or Kasimovian) in Namibia and therefore that the *Converrucosporites confluens* Opper Zone must range lower than previously thought. New evidence from South American sequences also suggests that *Converrucosporites confluens* occurs at horizons close to the level of the Carboniferous/Permian boundary (see Césari, 2007).

Thus Stephenson (2009) thought it necessary to recalibrate the ages of Oman biozones. The range of *Converrucosporites confluens* in Oman is well known (see Penney et al., 2008) and it is most common above the 2165A to 2141A interval thus the part of the Kuhlan Formation in question is likely Carboniferous in age. Of course these are new developments – radiometric dates have only recently been applied to Carboniferous and Permian rocks in Gondwana – and so there is a lot of uncertainty hence the question mark in Figure 4 of the paper between the Carboniferous and Permian columns. But some new evidence appears to suggest that rocks originally considered Early Permian (e.g. middle parts of the Al Khilata Formation and middle parts of Unayzah B; see for example Stephenson et al., 2003) are possibly late Carboniferous in age.

In regard to Al-Wosabi's request for more sedimentological information; as he says, this paper is not a sedimentological paper. Its purpose was simply to describe a few well-preserved and consistent assemblages. The photos in Plate 1 were included to give a brief sedimentological context to the paper. In fact the lithological description given in Figure 2 is quite detailed giving information on beds less than 1 m thick. There is certainly far more detailed description of the context of palynological samples than has been given in any previous palynological paper on the Carboniferous – Permian of Yemen.

In regard to Al-Wosabi's request for more discussion of the contact between the Kuhlan and Akbarah formations, the paper never intended to discuss the Akbarah Formation. We also have no direct palynological information from the latter formation. No comment is given about the boundary between the two formations because we feel it is not relevant to the paper. In the paper we simply suggest that the Akbarah Formation is probably not younger than the 2165A Biozone, which seems entirely reasonable.

Al-Wosabi feels that two samples are not sufficient to date the lower 60 m of the Kuhlan Formation. Here we disagree strongly. The two samples yielded very well preserved abundant assemblages. The first author (MHS) has personally examined the assemblages studied by Neves (in Kruck and Thiele, 1983) and by El-Nakhal et al. (2002). The assemblages from the Kuhlan Formation are by far the best-preserved in published accounts. In the paper we simply give a date for the lower part of the Kuhlan Formation from a 60 m section. The two samples were absolutely consistent in composition and - more importantly - were very similar to very well studied and understood sequences in nearby Oman. The first author (MHS) has personally studied these Oman sequences for more than ten years and the composition of the two Kuhlan samples allows a very coherent correlation with the Oman sequence.

The correlated sequences in Kuhlan and in the P1 and P5 production units in the Al Khilata Formation are also very similar lithologically. Thus we believe the correlation is very well founded. There is no statistical representation issue here. If, for example, an unequivocal Sakmarian foraminifer is found in a limestone, then the limestone must be Sakmarian in age. One single fossil can date a horizon. In this case many tens of palynomorphs offer a consistent and coherent case for a 2165A to 2141A age. This date is a very significant advance on the previous study by El-Nakhal et al. (2002) who reported on two samples collected from the Akbarah Formation at the Beit Al-Kooli section. Here only a tentative late Carboniferous to Early Permian age could be suggested.

Finally we believe that we have located the section very precisely in Figure 1. Full details of this locality are also given in Al-Mashaikie (2005).

REFERENCES

- Al-Mashaikie, S.Z.A. 2005. Lithofacies and petrography of siliciclastic red bed sequences: A new lithostratigraphic concept of the early Mesozoic Kuhlan Formation (NW Yemen). *Freiberger Forschungshefte, C507: Palaontologie, Stratigraphie, Fazies*, v. 13, p. 27-47.
- Beydoun, Z.R., M. As-Sururi, H. El-Nakhal, I. Al-Ganad, R. Baraba, A. Nani and M. Al-Awah 1998. *International Lexicon of Stratigraphy, Volume III. Fascicule 10b2*, International Union of Geological Sciences, Publication no. 34, 245 p.
- Césari, S.N. 2007. Palynological biozones and radiometric data at the Carboniferous-Permian boundary in western Gondwana. *Gondwana Research*, v. 11, p. 529-536.
- Diggins, J., R. Dixon, R. Dowin, J. Harris, M. Jakubowski, S. Mathews, D. Southwood and P. Ventris 1988. A geological model for the evolution of the Ma'rib-Jawf Basin, Yemen Arab Republic. Robertson Research International Limited and Hunt Oil Company. Unpublished Report no. 2616/IIb.
- El-Nakhal, H.A., M.H. Stephenson and B. Owens 2002. New Late Carboniferous – Early Permian palynological data from glacial sediments in the Kooli Formation, Republic of Yemen. *Micropaleontology*, v. 48, p. 222-228.
- Kruck, W. and J. Thiele 1983. Late Palaeozoic glacial deposits in the Yemen Arab Republic. *Geologisches Jahrbuch Reihe B: Regionale Geologie Ausland*, v. 46, p. 3-29.
- Penney, R.A., I. Al Barram and M.H. Stephenson 2008. A high resolution palynozonation for the Al Khilata Formation (Pennsylvanian to Lower Permian), South Oman. *Palynology*, 32, 213-231.
- Stephenson, M.H. 2008. A review of the palynostratigraphy of Gondwanan Pennsylvanian to Lower Permian glaciogenic successions. In C.R. Fielding, T.D. Frank and J.L. Isbell (Eds.), *Resolving the Late Paleozoic Ice Age in Time and Space*. Geological Society of America Memoir, 441, p. 317-330.
- Stephenson, M.H. 2009. The age of the Carboniferous-Permian *Converrucosisporites confluens* Opper Biozone: New data from the Ganigobis Shale Member, Dwyka Group, Namibia. *Palynology*, v. 33, p. 167-177.
- Stephenson, M.H., P.L. Osterloff and J. Filatoff 2003. Palynological biozonation of the Permian of Oman and Saudi Arabia: Progress and challenges. *GeoArabia*, v. 8, no. 3, p. 467-496.