PALEOCLIMATIC EVIDENCE FROM THE AREADO FORMATION, CRETACEOUS OF THE SÃO FRANCISCO BASIN, STATE OF MINAS GERAIS, BRAZIL *

KENITIRO SUGUIO ** AND JOSÉ HUMBERTO BARCELOS ***

ABSTRACT Though some papers have been published on the Areado Formation, which represents the basal deposit of the São Francisco Basin, State of Minas Gerais, Brazil, their paleoclimatic evidence was rarely considered. This contribution deal with the alluvial fan deposits, cross-bedding and associated structures as evidence of warm and very dry (probably desertic) paleoclimate during the greatest part of the Areado sedimentation. On the other hand, the miofloristic elements are suggestive of a mild paleoclimate, at least during the Quiricó facies, which probably represents only a short time interval of the Areado sedimentation.

RESUMO A Formação Areado engloba os depósitos basais da bacia sedimentar do São Francisco, Estado de Minas Gerais, Brasil. As evidências paleoclimáticas presentes em seus sedimentos foram raramente discutidas nos trabalhos publicados que tratam dessa formação. Este trabalho trata dos depósitos de leque aluvial e das estratificações cruzadas e estruturas presentes nessa formação sob o enfoque de suas contribuições para as inferências paleoclimáticas. Paleoclimas quentes e muito secos (provavelmente desérticos) prevaleceram durante o tempo de deposição dessa formação. Os elementos mioflorísticos, por outro lado, são sugestivos de climas mais amenos e mais úmidos, pelo menos durante a deposição de sedimentos da Fácies Quiricó. Representam, contudo, curto intervalo de tempo em relação ao tempo de sedimentação da Formação Areado.

INTRODUCTION In the São Francisco Basin, overlapping in angular unconformity the crystalline precambrian rocks of the Canastra and Bambuí Groups, there are sandstones rather clayey and silty covered by volcanic and volcanoclastic rocks. They have been identified by Oliveira (1881 p. 56) in the Alto Paranaíba region, State of Minas Gerais (Fig. 1), and introduced in Brazilian geologic literature by Rimann (1917 p. 30), who distinguished the Areado Sandstone (lower sandy formation) and the Capacete Sandstone (upper sandy formation).

Their relative ages and stratigraphic relationships are controversial and several subdivisions have been proposed by different authors. Though many classifications exist, none of them seem to be definite. Hence the scheme of Hasui *et al.* (1975), Barcelos & Suguio (1980) and Petri & Suguio (1983), with some modification is adopted. The names here used are: Areado, Patos, Capacete and Urucuia (Fig. 2).

While the Areado Formation, which was intensively studied by several authors and recently analysed in detail by Barcelos & Suguio (1980, 1981) and Suguio & Barcelos (1980), other formations are less known. Nevertheless, assuming that these Cretaceous sediments have been deposited by a single but very large and complex fluvial system (Barcelos & Suguio 1980), the paleoclimate outlined for the Areado Formation must be considered valid for all the sequence.

PALEOCLIMATIC EVIDENCE **Generalities** From bottom to top it is possible to recognize the following facies in the Areado Formation: Abaeté, Quiricó and Três Barras.

Figure 1 – Geologic map of partial extent of the Cretaceous continental deposits (São Francisco Basin) in the Alto Paranaíba region. Areado is the lowermost formation among the Cretaceous sediments

* Trabalho apresentado em 03/10/83 na "Penrose Conference on Cretaceous Climates", Florissant, Colorado, EUA.

** Instituto de Geociências, Universidade de São Paulo, Caixa Postal 20899, CEP 01000, São Paulo, SP, Brasil

*** Instituto de Geociências e Ciências Exatas – UNESP, CEP 13500, Rio Claro, SP, Brasil.

The last one is the thickest and most developed unit. Quiricó facies could be lacustrine and the Abaeté facies is alluvial fan deposits.

Possible paleoclimatic evidence of the Areado Formation is entirely related to the lithological properties.

Alluvial fan deposits According to Barbosa (1965), Cardoso (1968), Ladeira & Brito (1968), Barbosa *et al.* (1970) and Braun (1970), the Abaeté facies conglomerates filled up paleo-channels and could record a desertic paleoclimate at the beginning of the Areado sedimentation. On the other hand, according to Freyberg (1932) and Hasui (1969), their deposition could have occurred under fluvial subaqueous conditions, as alluvial fans related to Areado Basin peripheral mountainous area, where occurred occasional strong storms (Sad *et al.* 1971, Hasui *et al.* 1975).

faceted pebbles and cobbles suggesting an ancient eolian activity.

Not only the alluvial fan deposits, but also the occurrence of the partially preserved volcanic rock fragments, which allowed us to recognize their volcanic nature, as well as the ventifacts, are indicative of a dry paleoclimate.

Cross-bedding and associated structures The occurrence of conspicuous cross-beddings in Três Barras facies sandstones has been previously mentioned by Pflug (1961), Ladeira & Brito (*op. cit.*), Hasui (*op. cit.*), Braun (*op. cit.*), Sad *et al.* (1971) and Suguio *et al.* (1981). They are more typical of the paleo-channel sandstone, which are cyclically repeated in a vertical sequence, the newer ones truncating the older channel and floodplain deposits. They are mostly tangential at the base and medium (5 cm

Figure 2 -- Lithostratigraphy of the São Francisco Basin deposits subdivided into Areado, Patos, Capacete and Urucuiá Formations, with a detailed facies subdivision of the Areado Formation

The thickness of the conglomerates, which is related to the distance from the source-area, increases southwestwardly (Canastra arch and quartzites of the Bambuí Basin western margin), reaching to a preserved maximum thickness of 8 m.

These deposits are frequently constituted by sandstones with blocks of volcanic rocks (Suguio & Barcelos 1980), occupying paleo-channels. Near São Gonçalo do Abaeté, State of Minas Gerais, there are conglomerates with some

to 2 m) to very great (more than 8 m), using the Conybeare & Crook's scale (1968).

Another feature observed in these sandstones is the slump structure described by Pflug (*op. cit.*), Ladeira & Brito (*op. cit.*), Barbosa *et al.* (*op. cit.*) and Suguio *et al.* (1981). According to Selley (1976), the processes responsible for these structures are triggered by lateral movements related to earthquakes turbulent (density) currents or hydrostatic pressure. Syndepositional seismicity is also

suggested by frequent faults cutting the sandstone bedding.

These features, mostly the cross-bedding very well shown in the paleo-channel deposits, allow us to establish an analogy with the Pirambóia Formation of the Paraná Basin (Barcelos, 1979).

Hence it is suggested the similar paleoenvironmental conditions during the deposition to both the Pirambóia Formation and Três Barras facies of the Areado Formation are similar. According to Ladeira & Brito (*op. cit.*), Cardoso (*op. cit.*), Hasui *et al.* (1975) and Barcelos & Suguio (1980, 1981), this facies has been deposited in a fluvio-lacustrine environment.

Fossiliferous content Among the lithological units of the Areado Formation, only the Quiricó facies is fossiliferous, and the following fossils have been found: fish (Scorza & Santos, 1955), arthropoda (Santos, 1968), plant remains (Duarte, 1968), conchostraca (Cardoso, *op. cit.*) and ostracoda (Barbosa *et al.*, *op. cit.*). According to Sad *et al.* (*op. cit.*) the fossils from the Areado Formation have only limited chronological meaning, but they accepted the Albian-Aptian age suggested by Scorza & Santos (*op. cit.*) and Cardoso (*op. cit.*). According to Lima (1979), the predominance of the pollen *Inaperturopollenites crisopolensis* would be indicative of Barremian or at most lower Aptian age.

Lima (*op. cit.*) admitted a mild paleoclimate, between subtropical to temperate, based on the absence, both of the miofloristic elements indicative of warm climate (trilete spores and polylicate pollens) and that indicative of cold climate (disaccate pollens).

CONCLUSIONS Not only the occurrence of the alluvial fan deposits in the Abaeté facies of the Areado Formation but also their petrological properties, as the presence of partially weathered volcanic rock fragments, suggest a dry paleoclimate, probably desertic, during at least part of the Areado Formation deposition.

On the other hand, the cross-bedding and associated structures of the Três Barras facies mainly in view of its great similarities with those of the Paraná Basin Pirambóia Formation, bespeak a dry paleoclimate. In this context, the cross-bedded structures of the Três Barras facies could be partially attributed to eolian dunes.

The relatively restricted areal and stratigraphical distribution of the Quiricó facies is suggestive to represent a short time interval in Areado sedimentation context. Then, even if the mild paleoclimate idea of Lima (*op. cit.*) is correct, it seems that a warm and very dry (desertic) paleoclimate prevailed during the greatest part of the Areado sedimentation.

REFERENCES

- BARBOSA, O. — 1965 — Formação Areado. *Anais XIX Congr. Bras. Geol.*, Rio de Janeiro (resumo).
- BARBOSA, O., BRAUN, O. P. G., DYER, R. C., CUNHA, C. A. B. R. — 1970 — Geologia da região do Triângulo Mineiro. DNPM/DFPM, Boletim 136:140 pp., Rio de Janeiro.
- BARCELOS, J. H. — 1979 — Arenitos cretácicos do Alto Paranaíba (Minas Gerais): Proveniência e ambientes de sedimentação. Tese de Doutorado, Instituto de Geociências, Universidade de São Paulo, 181 pp., São Paulo (inédito).
- BARCELOS, J. H. & SUGUIO, K. — 1980 — Distribuição regional e estratigráfica das formações cretácicas do Oeste Mineiro. *Anais XXXI Congr. Bras. Geol.*, 2:683-690, Camboriú.
- BARCELOS, J. H. & SUGUIO, K. — 1981 — Estudos sedimentológicos da Formação Areado, Cretáceo da Bacia Sanfranciscana. Minas Gerais. *Rev. Bras. Geoc.*, 11(4):247-256, São Paulo.
- BRAUN, O. P. G. — 1970 — A Formação Areado e a Formação Serra Negra. *Rev. Esc. Min.*, XXVIII (3):100-106, Ouro Preto.
- CARDOSO, R. N. — 1968 — Contribuição ao estudo da Formação Areado: Estratigrafia e descrição de filópodes fósseis. Comunicação XXII Congr. Bras. Geol., Belo Horizonte.
- CONYBEARE, C. E. B. & CROOK, K. A. W. — 1968 — Manual of Sedimentary Structures. *Geol. and Geoph. Bull.*, Cambera, Aust.
- DUARTE, L. — 1968 — Restos vegetais fósseis da Formação Areado. Comunicação XXII Congr. Bras. Geol., Belo Horizonte.
- FREYBERG, B. VON — 1932 — Erbnisse geologischer Forschungen in Minas Gerais (Brasilien). *Neus Jb. Min. Paleon.*, II, 401 pp. Trad. de J. M. Campos, XIX Congr. Bras. Geol., Rio de Janeiro.
- HASUI, Y. — 1969 — O Cretáceo do Oeste Mineiro. *Bol. SBG*, 18(1): 39-56, São Paulo.
- HASUI, Y., SADOWSKI, G. R., SUGUIO, K., FUCK, G. F. — 1975 — The Phanerozoic tectonic evolution of the western Minas Gerais State. *An. Acad. bras. Ciênc.*, 47 (3/4):431-438, Rio de Janeiro.
- LADERIA, E. A. & BRITO, O. E. A. — 1968 — Contribuição à geologia do planalto da Mata da Corda. *Anais XXII Congr. Bras. Geol.* 181-199, Belo Horizonte.
- LIMA, M. R. — 1979 — Palinologia dos calcários laminados da Formação Areado, Cretáceo de Minas Gerais. *Atas 2º Simp. Reg. Geol.*, 1:203-216, Rio Claro.
- OLIVEIRA, F. P. — 1881 — Exploração das minas de galena do ribeirão do Chumbo, afluente do Abaeté. Estudo da zona percorrida de Ouro Preto até esse lugar. *Anais Esc. Min.*, 1:39-105, Ouro Preto.
- PETRI, S. & FULFARO, V. J. — 1983 — *Geologia do Brasil (Faneozóico)*. T. A. Queiroz e Ed. USP. 631 pp., São Paulo.
- PFLUG, R. — 1961 — Deslizamento sinsedimentário em arenitos com estratificações cruzadas da Série Urucua em Canoeiros, Minas Gerais. *Rev. Eng., Mineração e Metalurgia*, XXXII (197): 242, Rio de Janeiro.
- RIMANN, E. — 1917 — A kimberlita no Brasil. *An. Esc. Min.*, XV: 27-32, Ouro Preto.
- SAD, J. H. G., CARDOSO, R. N., COSTA, M. T. — 1971 — Formações Cretáceas em Minas Gerais: Uma revisão. *Rev. Bras. Geoc.*, 1(1):2-13, São Paulo.
- SANTOS, R. S. — 1968 — Um novo artrópodo da Formação Areado, Estado de Minas Gerais. Resumo de Comunicações, XXII Congr. Bras. Geol., Belo Horizonte (Minas Gerais).
- SCORZA, E. P. & SANTOS, R. S. — 1955 — Ocorrência de folhelho fossilífero cretácico no município de Presidente Olegário, Minas Gerais. DNPM/DGM, Boletim 155:27 pp. Rio de Janeiro.
- SELLEY, R. C. — 1976 — *An Introduction to Sedimentology*. Academic Press. London: 408 pp.
- SUGUIO, K. & BARCELOS, J. H. — 1980 — Influência do vulcanismo alcalino na sedimentação cretácica do Oeste Mineiro. *Anais XXXI Congr. Bras. Geol.*, 5:3013-3023, Camboriú.
- SUGUIO, K., BARCELOS, J. H. J., SOUZA, S. H. M. — 1981 — As estruturas sedimentares da Formação Areado, Cretáceo da Bacia Sanfranciscana, Minas. *Atas 2º Simp. Reg. Geol.*, 2:147-161, Curitiba.

MANUSCRITO

Recebido em 10 de novembro de 1983

Revisão aceita em 17 de novembro de 1983