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Radio-Carbon Datings of Ancestral River Sediments on the Riverine Plain of South-eastern Australia and Their Interpretation

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Abstract—This paper deals with the configuration of Quaternary sediments of the Riverine Plain. The origin of fluviatile sediments and their relationship to the present river system is discussed. It is shown that the Older Alluvium of the Plain is relatable to a series of prior streams which are still traceable as a relict distributory stream system. The Younger Alluvium is deposited by ancestral rivers which form a tributary pattern. The ancestral river system displays evidence of three separate phases of stream activity. Radio-carbon datings of wood samples from sediments representative of the three phases are presented. Results substantiate the earlier published relative chronology. A palaeo-climatic interpretation of the presented carbon dates, and those published previously, is put forward.

The purpose of this paper is to present new datings of three reliable carbon samples obtained from ancestral river sediments and to correlate these with earlier published dates. With relatively few dates available at this stage, inferences drawn from the limited data should still be regarded as contributions towards an eventual understanding of the region's geochronology.

Surface sediments of the Riverine Plain consist of two geological subdivisions: the Older and Younger Alluvium. Sediments deposited by prior streams (Butler, 1950) are the Older Alluvium, while Younger Alluvium consists of the ancestral river (Coonambidgal) sediments. The datings presented in this paper are from the Younger Alluvium.

The near-perfect preservation of prior streams on the present Older Alluvium surface in some locations was first taken as evidence for a very youthful age. However, subsequent studies showed that they are of considerable antiquity, and regional stratigraphic studies confirm this.

Carbon samples occurring conformably in current bedded sands and gravels of stratigraphically the most recent prior stream beds, gave C14 age determinations of greater than 36,000 years (Pels, 1964*a*). This determination of age represented the limit of the dating equipment, so that it is not known how much older the sediments are.

On the other hand, Langford-Smith (1963) published dates of wood samples obtained from shallow depths in prior streams which indicated a much younger age. He attributed these dates to possible reactivation of prior stream beds during floods or root growth not related to the time of deposition.

Regional surveys (Pels, 1964*b*, 1966) have shown that the ancestral river system quite definitely post-dates the period of prior stream activity. This can be demonstrated generally over the Plain in N.S.W. and is substantiated by soils studies (Butler, 1958).

The two papers (Pels, *loc. cit.*) dealt with the surface configuration of the ancestral river system and subsurface geological aspects respectively. Both stressed the geochronological importance of movement along the Cadell Fault which enabled ready determination of three separate phases of river activity. It was shown that there is a non-diverted phase (Coonambidgal I) and two diverted phases (Coonambidgal II and III) and that each phase consisted of a degradational and aggradational sub-phase.

Carbon Datings

Datings of samples collected during the regional survey, which formed the basis of the two earlier papers, have now become available. Results of these datings substantiate the earlier postulations.

The radio-carbon datings were carried out by the Department of Nuclear and Radiation Chemistry of the University of New South Wales on samples obtained from sediments representing the three aggradational sub-phases, as follows.

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Coonambidgal I

This depositional system has a width of one mile and is clearly delineated on the Cadell Tilt Block near Womboota. It is a filled-in river unaffected by further river activity because of movement along the Cadell Fault. It represents both a downcutting and infilling phase. A carbon sample was obtained from the centre of this system at a depth of 6′ 6″. It formed a layer of carbon conformably interbedded with thin layers of gravel. The site's location is :

Portion 16, Parish of Womboota, County of Cadell, N.S.W.

Geographic co-ordinates : 35° 54′ S. ; 144° 41′ E.

Sample No. : 67/12 N.S.W. 31.

Age : Exceeding 28,600 years, i.e. beyond the limit of the equipment.

Coonambidgal II

It is known from stratigraphical evidence and the drastic diversion pattern of the ancestral river system near Mathoura (see Fig. 1) that this system again represents a downcutting phase with subsequent infilling. The fill is now represented by the higher older terrace along the Edward River at Deniliquin. The carbon sample, obtained from a borehole in this terrace, was a fragment of a knotted tree branch and definitely an aerial part. It was obtained from a depth of 40′ in State Forest No. 397, Parish of South Deniliquin, County of Townsend, N.S.W.

Geographic co-ordinates : 35° 32′ S. ; 144° 58′ E.

Sample No. : 67/14 N.S.W. 32.

Age : 24,050$\pm$835 years.

Coonambidgal III

There is a further distinct system of younger alluvium which can be traced adjacent to the Bullatale Creek between Tocumwal and Deniliquin. Near the latter town it becomes superimposed on the Coonambidgal II sediments associated with the Edward River. It now forms the lower terrace adjacent to the Edward River near Deniliquin (for details, see Pels, 1966, p. 34).

A deep trench was excavated across the lower terrace during construction of the Lawson siphon. This siphon, which was constructed to take irrigation supplies across the lower flood-plain (terrace) of the river, is restricted to this terrace and an elevated canal was constructed on the higher Coonambidgal II sediments.

The carbon sample was a block of wood cut out of a log encountered at a depth of 15′ during excavation. Its location is described as State Forest No. 397, Parish of South Deniliquin, County of Townsend, N.S.W.

Geographic co-ordinates : 35° 34′ S. ; 145° 01′ E.

Sample No. : 67/13 N.S.W. 33.

Age : 9,800$\pm$200 years.

The three datings indicate a definite chronological sequence. If the position of the Coonambidgal I sample within the sediments (6′ 6″ from the surface) were taken as an indication, it could be inferred that the age of greater than 28,600 years applies to the final stages of the infilling phase of Coonambidgal I.

The second date of 24,050 years would apply to the early stage of the infilling phase of Coonambidgal II (40′ from the surface) and the age of 9,800 years would also represent an early stage of infilling of Coonambidgal III. It is likely that the total phase of infilling occupied a considerable period of time.

This point is important when further correlations are attempted with other carbon datings from the region. From stratigraphical evidence the sequence of ancestral river activity of the Goulburn and Murray systems is visualized as shown in Fig. 1.

Bowler (1967) has published a date for ancestral river sediments associated with the Goulburn River near Shepparton showing an age of 30,600$\pm$1,300 years (N298).

It is known that the three phases are superimposed at this location, and the dated sediments would therefore represent Coonambidgal I. The sample from Womboota (>28,600) could be of similar age, and this lends weight to the mapping of Coonambidgal I as shown in Fig. 1.

At the same location near Shepparton, younger sediments were dated as 26,200 and 24,500 years, and these dates again do not conflict with that determined for the Coonambidgal II near Deniliquin (24,050$\pm$835 years).

As can be seen from Fig. 1, the three phases are superimposed in some locations, but in others become laterally separated. Because of this, it was possible to establish (Bowler, 1967 ; Pels, 1966) that source-bordering sand dunes are common on the leeward side of Coonambidgal II ancestral rivers.

From this and other evidence, Bowler dated Coonambidgal II sediments at three further locations (samples N301, ANU29 and N296) (Bowler, 1967), which showed dates of 16,600$\pm$400, 13,500$\pm$700 and 13,400$\pm$340 years respectively.

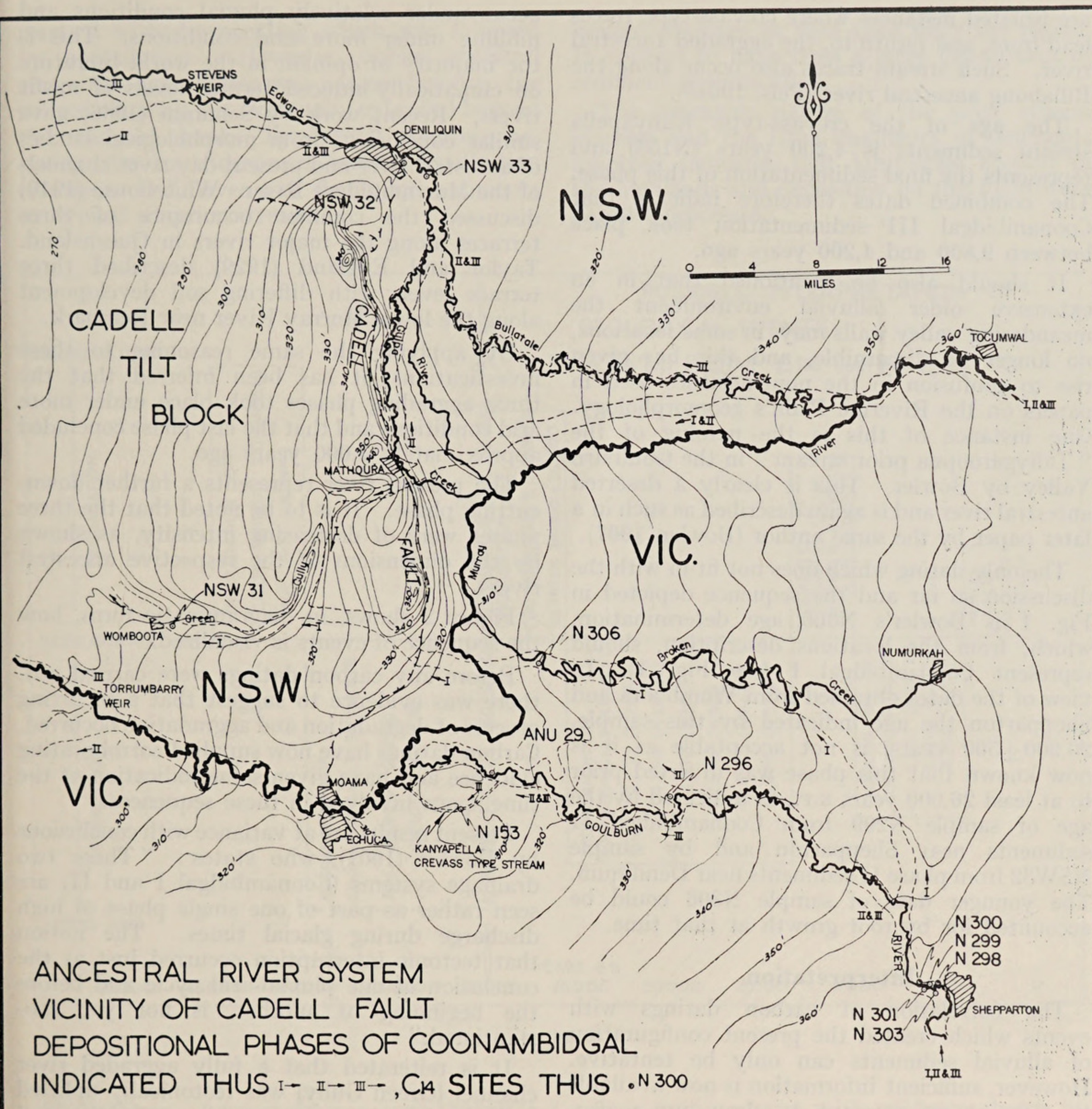

FIGURE 1.

The known dates of Coonambidgal II sediments therefore range from 26,200 to 13,400 years.

A further series of dates quoted by Bowler and ranging from 8,320±160 to 4,200±130 years appear to represent Coonambidgal III sediments of the Goulburn ancestral river system.

Bowler and Harford (1966) described sample N153 as having been derived from the Kanyapella prior stream. The present author suggests that this is a crevass-type stream which can be traced as leaving the final deposition of the third phase ancestral Goulburn (Coonambidgal III) and returning on to it as a continuous trace.

Except for the source-bordering sand dunes, deposition during the aggrading phases was generally restricted to the old river channel (valley fills in meandering valleys), but there are isolated instances where crevass-type traces lead from, and return to, the aggraded ancestral river. Such stream traces also occur along the Billabong ancestral river (Pels, 1964*b*).

The age of the crevass-type Kanyapella stream sediments is 4,200 years (N153) and represents the final sedimentation of this phase. The combined dates therefore indicate that Coonambidgal III sedimentation took place between 9,800 and 4,200 years ago.

It should also be mentioned that in an extensive older alluvial environment the meandering valley walls may, in some locations, no longer be discernible, and this has given rise to confusion in the nomenclature used in papers on the Riverine Plain's geomorphology. One instance of this is the naming of the " Tallygaroopna prior stream " in the Goulburn Valley by Bowler. This is clearly a deserted ancestral river and is again described as such in a later paper by the same author (Bowler, 1967).

The only dating which does not fit in with the discussion so far and the sequence depicted in Fig. 1 is Bowler's N306 age determination, which, from the locations description, should represent Coonambidgal I (see Fig. 1). In view of the dates obtained from Womboota and Shepparton the age indicated by this sample, 20,900±500 years, is not acceptable as it is now known that this phase was diverted prior to at least 26,000 years B.P., as indicated by the age of sample N299 from Coonambidgal II sediments near Shepparton and by sample NSW32 from phase II sediments near Deniliquin. The younger date of sample N306 could be accounted for by root growth at that time.

Interpretation

The correlation of carbon datings with events which created the present configuration of alluvial sediments can only be tentative. However, sufficient information is now available to warrant an attempt to draw up a geochronology and to draw from it palaeoclimatological inferences.

This information includes, apart from the C14 datings,

(i) the clear diversion pattern of ancestral rivers around the Cadell Fault,
(ii) the readily recognizable surface expression of these former river systems,
(iii) the widely separated independent courses of the river in some locations and superimposition in others.

In earlier papers it has been stated that downcutting of a river channel is thought to occur under relatively pluvial conditions and infilling under more arid conditions. This is the majority of opinion in the world literature on climatically-induced terrace levels of misfit rivers. Recent work by Schumm (1966) gave similar conclusions from morphological studies of ancestral river and present-day river channels of the Murrumbidgee River. Whitehouse (1940) discussed the common occurrence of three terraces along the major rivers in Queensland. Taylor and England (1929) described three terrace levels with differing soil development along the lower Murray River near Renmark.

By applying the same reasoning to these investigations, it has been inferred that the three aggrading phases took place under more arid conditions and that the last phase concluded approximately 4,000 years ago.

The present river represents a further downcutting phase. It is to be noted that the three phases were of decreasing intensity, as shown by the dimensions of the respective ancestral rivers.

Figure 2 shows, in diagrammatic form, how the sequence of events is visualized.

Before any carbon datings were carried out, there was evidence to suggest that a recurring process of degradation and aggradation occurred. Carbon datings have now supplied corroborating evidence and have given some indication of the time spans involved in these sequences.

Present results are at variance with conclusions by Bowler (1967), who states : " These two drainage systems (Coonambidgal I and II) are seen rather as part of one single phase of high discharge during glacial times. The notion that tectonic interruption occurred just at the conclusion of one pluvial-arid cycle and before the beginning of another, is not yet substantiated."

It is reiterated that a fully aggraded river channel (Green Gully) was tectonically uplifted and that the subsequently newly created diverted ancestral river now also forms a deeply incised and subsequently filled channel, thus indicating that consecutive pluvial-arid phases were responsible.

Recurring climatic fluctuations can be traced further back into the geological history of the Plain.

Sections bored through prior streams (Pels, 1964*a*) commonly show a distinct vertical break from sand and gravel at the bottom of the stream bed to heavy clay. This abrupt break, together with characteristic shapes of incised channels, indicates that prior stream phases also commenced with downcutting which was followed by aggradation. However, unlike ancestral rivers this aggradation was not restricted to the incised channels but eventually extended beyond the channel banks by lateral overtopping, giving rise to widespread lateral distribution of stream bed, levee and floodplain sediments so typical of prior streams.

limited drainage at that time from the region. It appears to have been a large inland area of sediment accumulation.

The extensive nature of the prior stream systems and the large quantities of sediments involved indicates that large-scale erosion in the highlands and deposition on the Plain were parallel processes.

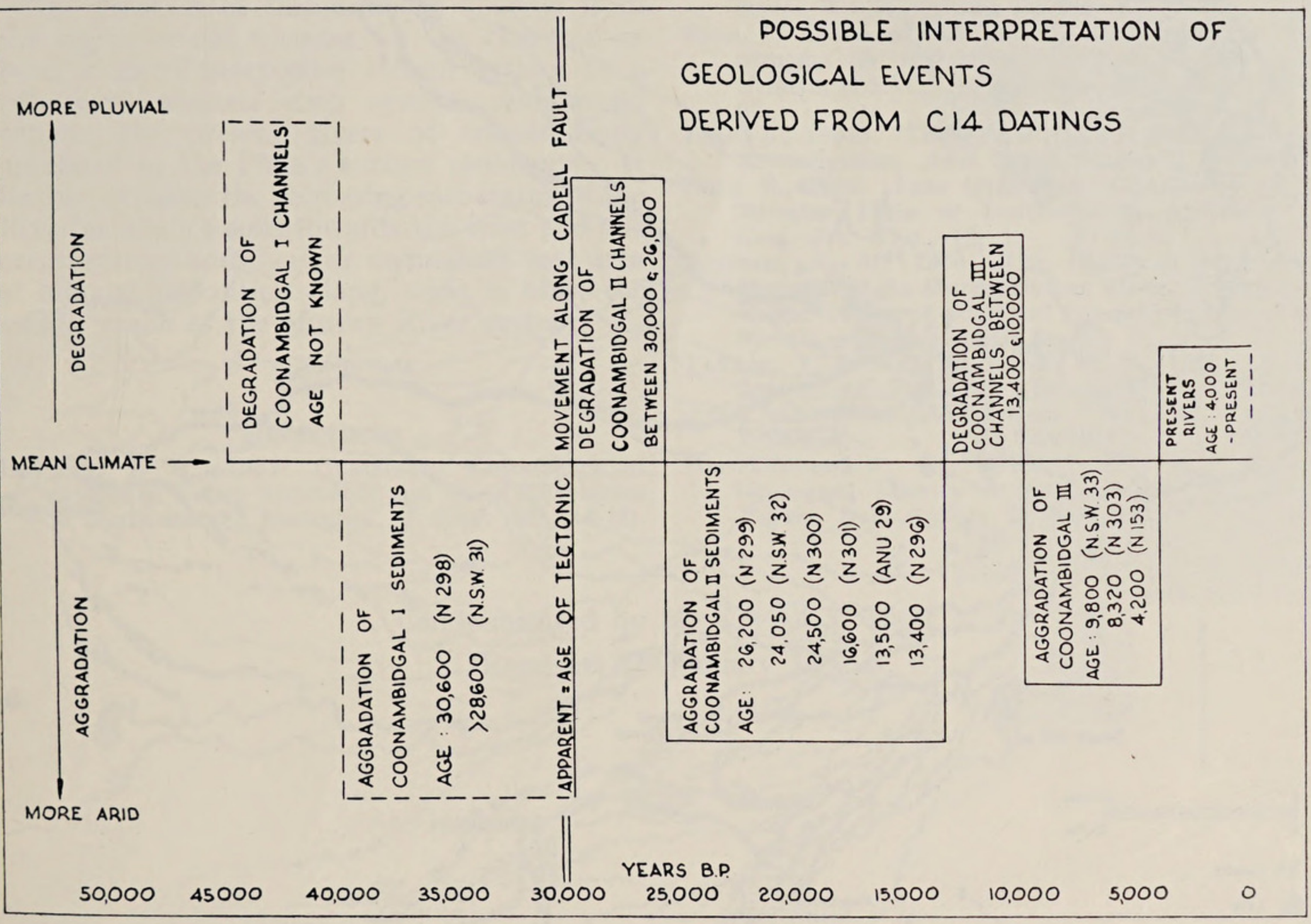

Figure 2.

The pattern of prior streams over the plain is not visualized as having been actively depositing simultaneously, and several phases of deposition and diversions to lower lying areas are probably responsible for the present distributary pattern of prior stream traces (see Fig. 3).

The definite change from prior streams to ancestral rivers warrants further consideration. It represents a major change in the drainage system of the region.

The distributary pattern of prior streams over the Plain and its dissipating nature towards the west suggests that there was very

This is in contrast with evidence shown by ancestral rivers. From the general occurrence of terraces along the entire river, it is clear that the process of degradation (and later aggradation) was synchronous along the entire river course. Terraces are common along the Murray River in the upper reaches and also in South Australia. Where they are absent in the central sector, they have been accounted for as deserted floodplains.

Furthermore, the prior streams form a distributory pattern, while ancestral rivers form a tributary system (Fig. 3).

Such an overall change in the behaviour of rivers and streams suggests a drastic change in

FIGURE 3.—The Riverine Plain in New South Wales.
(Drawn by W. Mumford, A.N.U.)

the drainage system of the Plain and there is evidence to substantiate such a postulation. The western fringe of the Riverine Plain consists predominantly of heavy-textured fluviatile sediments, indicating semi-lacustrine conditions of deposition and evaporite accumulation. It contains numerous lake and lunette relicts and Mallee outliers. Prior stream patterns generally dissipate before reaching this zone.

Surface water penetrated the lower lying areas of the Mallee, and chains of lakes are known to have occurred where the present Murray course is now located. There are remains of lunettes adjacent to the river, and preserved lakes occur in its vicinity. The great chain of lakes at the end of Willandra Creek, which branches off the Lachlan River near Hillston, forms a similar set of landscape conditions.

The absence of older alluvial (prior stream) sediments along the Murray River west of Wakool Junction suggests that this is a " post-prior stream " course which now drains the area.

The creation of this drainage channel from the region would account for the change-over from a distributory-prior stream system to a tributary ancestral river system, and would explain the present rivers of transit being unrelated to the Plain's surface sediments. It further explains the increasing salt status of the Riverine Plain's soils towards the west and the occurrence of an otherwise anomalous vast area of alluvial deposition along, what is now, the middle reach of the Murray River system.

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