[1296]

REMOTE SENSING APPLICATION AND QUANTITATIVE APPROACH BASED ON MODERN STUDY OF GEOMETRY RESERVOIR SANDSTONE REPRESENTATION OF SURFACE AND SUBSURFACE CEYHAN AND SEYHAN RIVER ADANA BASIN , TURKEY

Hasan Rosyadi[1], *Senem Tekin*[2]

[1]Çukurova Üniversitesi, Müh-Mim. Fakültesi Jeoloji Mühendisliği Bölümü, 01130 Email: hrosyadi@student.cu.edu.tr
[2]Çukurova Üniversitesi, Müh-Mim. Fakültesi Jeoloji Mühendisliği Bölümü, 01130 Email: senemtekin01@gmail.com

ABSTRACT

DEM and quantitative function is good combination for morphological study. Comparative image surface with representative channel seismic slice in subsurface and field observation that support of quantitative analysis, DEM and Landsat image. It is valuable data to support for geomorphology and geometry data that produced exploration data in Seyhan and Ceyhan river.Methods of sampling used number measurement representation both of river which selected on research areas. Population selected in Seyhan and Ceyhan River as representative location and sample. It involves data collection form field observation, company report, last publication and variables of river geomorphology from ESRI, Google Earth and ASTER DEM. Seismic slice image has compared with modern surface in Seyhan and Ceyhan. Well data has interpreted based on sequence stratigraphic and 2D,3D model to know sand distribution in modern Fluvial deltaic system. Field observation used to analogue the real condition land of rivers.Seyhan and Ceyhan River is indicated by meandering river from numerical calculation, comparative from DEM calculation and observation that data width ranges from > 500 m to <4000m (Seyhan) and < 6000m (Ceyhan). Data is controlled by bed load (dominant) on cross-plot CW vs SI, ML vs CL, RC vs SI, ML vs MBW, some mixed load, and few a suspended load. Heterogeneous grain sediments inside sinuosity channel suggested channel condition from mixed load Transport River.Combination DEM and quantitative is one of support data for geologic interpretation that is useful in distribution reservoir, sequence stratigraphy, correlation, dimension channel, sand bodies and area prediction.

Keywords: Seyhan, Ceyhan, DEM, Quantitative, Adana Basin

1.INTRODUCTION

Quantitative techniques, comparison data surface with subsurface, earth image and DEM analysis is valuable data to support geometrical analysis that produced new insight exploration data in Adana Basin. Modern fluvial deltaic depositional settings bring unmistakable geomorphological data to help of quantitative interpretations for numerical characterization of subsurface. Geomorphological data from modern fluvial deltaic analogs can give connection to seismic data, facies associations in three-dimension models where is controlled by geomorphology. This paper based quantitative models determine influence that variable of widths and lengths for sand body distribution. Comparison modern log with sequence depositional can make good vision of image depositional of sand.

2.METHOD

Information this paper consists a morphology statistic, sedimentation, diagram, bankfull, valley, channel size, shape, width, length and well information. Population selected in Seyhan and Ceyhan River as representative sample. Methods of sampling used number measurement representation both of river selective location. The sequence and depositional environment interpretation of materials describe influence tidal to fluvial and transport of sediment in coast. This information is required to understand as preliminary in fluvial deltaic system include interpretation of the sediment size, range from DEM, earth image and log lithology. It involves data collection on paper, company report, last publication and variables of river geomorphology from DEM, ESRI and Google earth. Measurement of fluvial morphometric used landsat image which analysis from north (upstream) to south (downstream) that data set collected from channel length (CL), sinuosity (SI) channel width (CW), radius of curvature (RC), meander wave length (ML), and meander belt width (MBW) both of river (Rohmana et al 2014). The aim is predict condition, channel shape, composition river lithologies and geometry. Similar analysis for the estimation of channel width from maps by Sear et al. (2001) gives an error of +/- 4m, which for smaller channels may represent a whole channel width.

3.MEASUREMENT MORPHOLOGY AND TYPES RIVER

Cukurova planform and delta plain is modern fluvial deltaic plains on southern part of Neogene where Ecemis Fault Zone in the west, Taurus Mountains in north, Amanos mountains in east. The age of sediments is Pleistocene

± Recent which superimpose discordantly with Neogene directly south of Adana (Figure 1). Geomorphological properties of the delta plain has been studied by (Erinc, 1953) and (Goney, 1976) that Cukurova plain was created by the Ceyhan, Seyhan and Berdan rivers and it has changed it developments sometimes through evolution. Ancient Seyhan river has made a delta where location near Tuz lake and Aktayan Lake (Kemal Gürbüz, 1999).

Channel east (Ceyhan) and west (Seyhan) is major river in Adana which dominant low sinuosity (1.0-1.3) and moderate sinuosity (1.4-1.7) channel. Seyhan River indicated near high sinuosity (2.5) channels that is categorized by progressed of meanders scroll bars (S wales and ridges), abandoned channels, oxbow lakes and lateral accretion. Low to moderate depth for moderate sinuosity can identify based on width ratio that muddy to mixed-sediment dominant classified of channel. Additional part for low sinuosity was recognized by non-meandering scroll bars development with vertical accretion, relatively straight channels and a moderate to high ratio of depth and width channel. Coarse sediments generally filled in low-sinuosity river with bed load transportation. Both channel categories is controlled by quaternary deposit, structures, bedrock and morphology. 56 morphometric analysis and measurements of Ceyhan and Seyhan River has been counted to make a prospect of fluvial geometry which statistical analysis of channel width both of river. Middle Upstream located in Adana city where downstream in Baharli until Mediterranean. We measured and analysis 20 data along river. Ceyhan River middle upstream located in Sogukpinar-Ceyhan where downstream in Yumutarlik. 36 data has been measured along river

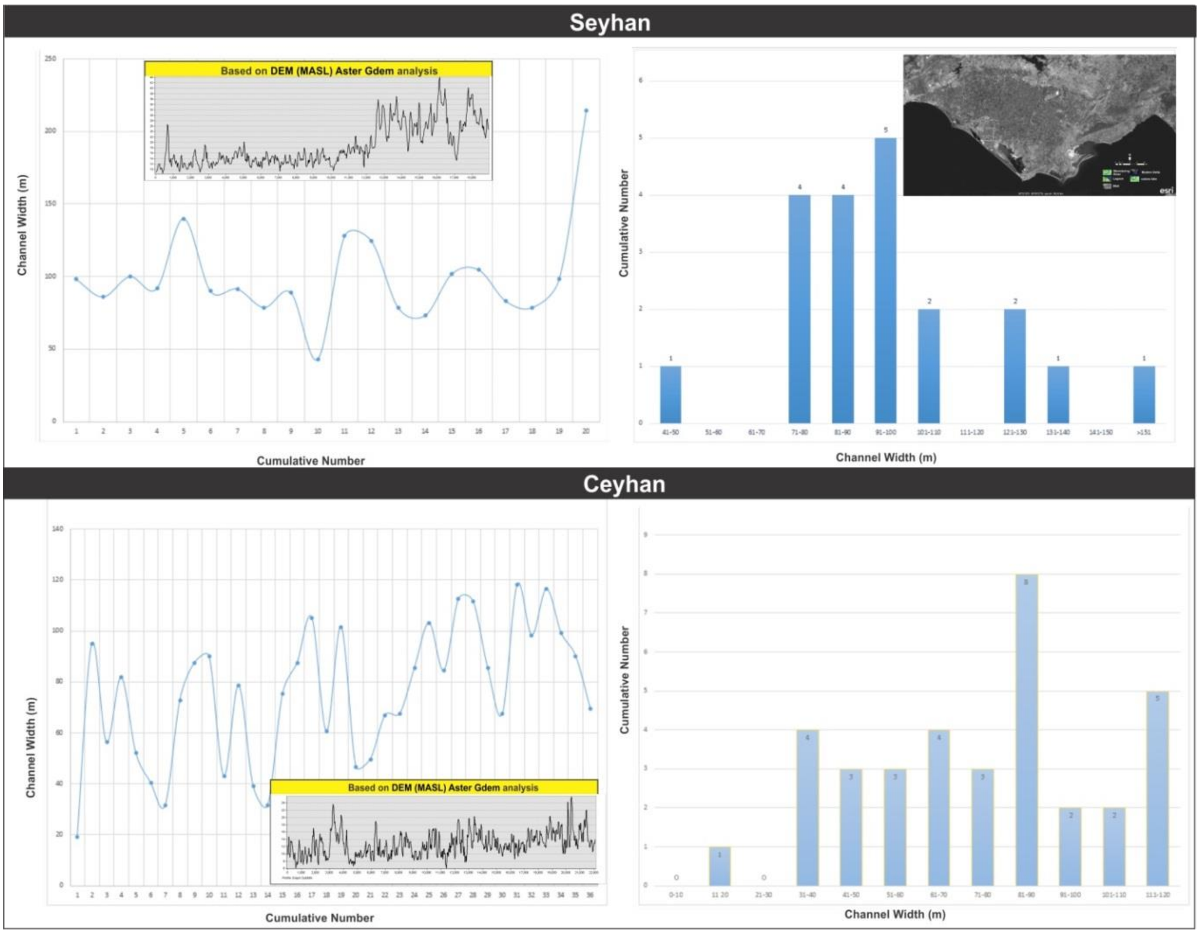

Figure 1. Map Index from ESRI shows Adana Basin where west is Seyhan River and east Ceyhan River. a) (left) Cumulative prospect of channel width and compared with analysis with curve of DEM b) (right) histogram measurement chart is replicates distribution of channel width and ranges from 43- 243 for Seyhan, Ceyhan (range 19-118 m) source of total length of channel each unit valley length (termed sinuosity), and meandering river system interpreted as based on degree and definitions of channel planform (after Rust, 1978)

Progress of meandering in alluvial rivers based on interaction between flow and sediment transport creates a sequence that increase the meandering flow and can pledgee bank erosion with time development the original sinuous planform (after Lewin, 1976). Nonexistence of synchronicity between pool-riffle positioning and meander bend wavelength is helpful indicator of passive meandering which channel was correcting planform and bedform concurrently (Thorne 1997).

4.STATISTIC AND ANALYSIS SEYHAN AND CEYHAN RIVER

Cukurova plain has sediment from Seyhan river that most sediment supply on it. Paleozoic and Mesozoic rocks (generally carbonates and ophiolites), Terrigenous, Miocene sedimentary rocks is influential in this river(Kemal

Gürbüz, 1999). Currently Seyhan River has daily flow of around 250.000m³ (Seyhan) west and 210.000m³ (Ceyhan) East with shared capacity of 520.000m³/d DSI. Drainage area and Sediment yield of Ceyhan is 20466 km2, 5461x103 tons yr-1 and Seyhan river 19352 km2, 5249x103 tons yr.—1 (DSI 1984 in Aksu et al 2014). Development of the river also controlled by quaternary deposit that contribute development of river. High-sinuosity river system established in middle down of Seyhan River until delta where northeastern fan has a frequently spaced, SW dipping listric extensional fault with SW dipping, detachment surface of bedding parallel. The listric extensional fault is WSW dipping and NNW striking that very repeatedly spaced where location in southwestern Adana Basin (Burton-Ferguson et al., 2005). The pattern and slope adjustment indicate subsident where cut off channel and sinuous channel. In the middle-downstream area near Ceyhan River that development of river is mainly controlled by Misis-Kyrenia fault zone (from Aksu et al., 2005; Walsh-Kennedy et al., 2014) and bedrock of Misis High. Pattern channel uplift history's indicated by sinuous and cut off channel with different style in upstream to middle. Subsiding marked also present in channel pattern in downstream in Ceyhan River.

Morphometric measurement exposes that channels width (CW) of the Seyhan River ranges from 43 to 214 m (mean: 99.7 m, median: 91.5 m, mode: 78.7 m), meander belt width (MBW) extending from 86 to 1922 m (mean: 819.7 m, median: 877.6 m, mode: N/A m), meander wavelength (ML) varieties from 674.5 to 3993 m (mean: 1595 m, median: 1261 m, mode: N/A), and radius of curvature (RC) arrays from 60 to 1084 m (mean: 417.1 m, median: 425.8 m, mode: 196 m). Morphometric measurement known that channels width (CW) of the Ceyhan River extending from 19 to 118 m (mean: 75.5 m, median: 80.1m, mode: 31.5m), with meander belt width (MBW) from 155.5 to 2851 m (mean: 923.8 m, median: 732.5 m, mode: N/A m), meander wavelength (ML) arrays from 595 to 3929 m (mean: 2241.5 m, median: 2007.8 m, mode: N/A), and radius of curvature (RC) from 170 to 1406 m (mean: 573.8 m, median: 522.1 m, and mode: 871.8 m) (Figure 2).

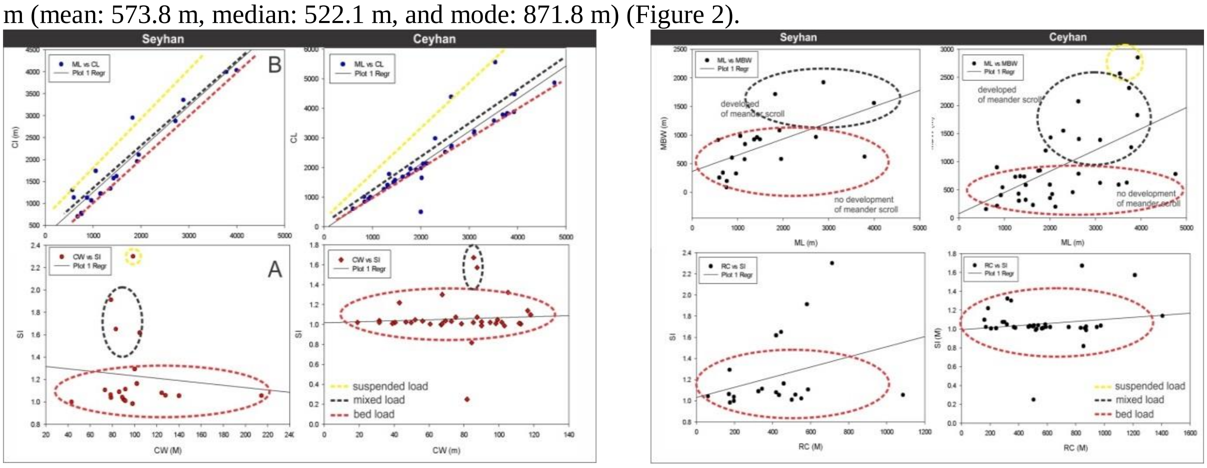

Figure 2. (left) Cross-plots show connection of morphometric parameter in Seyhan and Ceyhan River. a) Channel Width (CW) versus Sinuosity (SI); b) Meander Wavelength (ML) versus Channel Length (CL). (Right) Cross-plots of morphometric parameter in the Seyhan and Ceyhan River. (Bottom side) Radius of Curvature (RC) versus Sinuosity (SI); (Upside) Meander Wavelength (ML) versus Meander Belt Width (MBW).

Normally, Amalgamation of meander ring growth and phase difference in some stage of fluvial point-bar deposition, meandering channel migration and progressive side accretion consent width of sand body to possibly reach local channel meander width (Allen, 1965, 1982). The function of channel cross-section dimensions is a part of orderly by fluvial discharge meander wavelength (Leopold et al., 1964; Allen, 1982). Straight channel (SI < 1.4) illustrations low-sinuosity and channel width less than 140 m (Figure 2 Seyhan) and Straight channel for Ceyhan (SI < 1.4) displays low-sinuosity and channel width from 20- 120 m (Figure 2 Ceyhan). Quantitative morphometric analysis of Seyhan and Ceyhan rivers has a similar result which Cross-plots channel width (CW) versus sinuosity (SI) show main population trends. Data is controlled by bed load (dominant) and some mixed load channel with meandering system width ranges from > 500 m to <4000m (Seyhan) and < 6000m (Ceyhan). Cross-plots of meander wavelength (ML) versus channel length (CL) shows regressive population trends. Bed load transport rivers where potential meander wavelength is monitored by rises of channel (few data) length but mixed load channel lengths that larger than the meander wavelength (few data above the line at Figure 2 upside).

The radius of curvature (RC) oppose to sinuosity (SI) relationship infers that mixed and suspended rivers have values that reaching up 1.4 to 4 with area of curvature over 400 m to < 1200 m that representative of meandering system (Figure 2). Groups of same bed load transport is possibly associated with alluvial deposit, part of bedrock, and 'structural' which normal listric extensional fault group in Adana Basin.

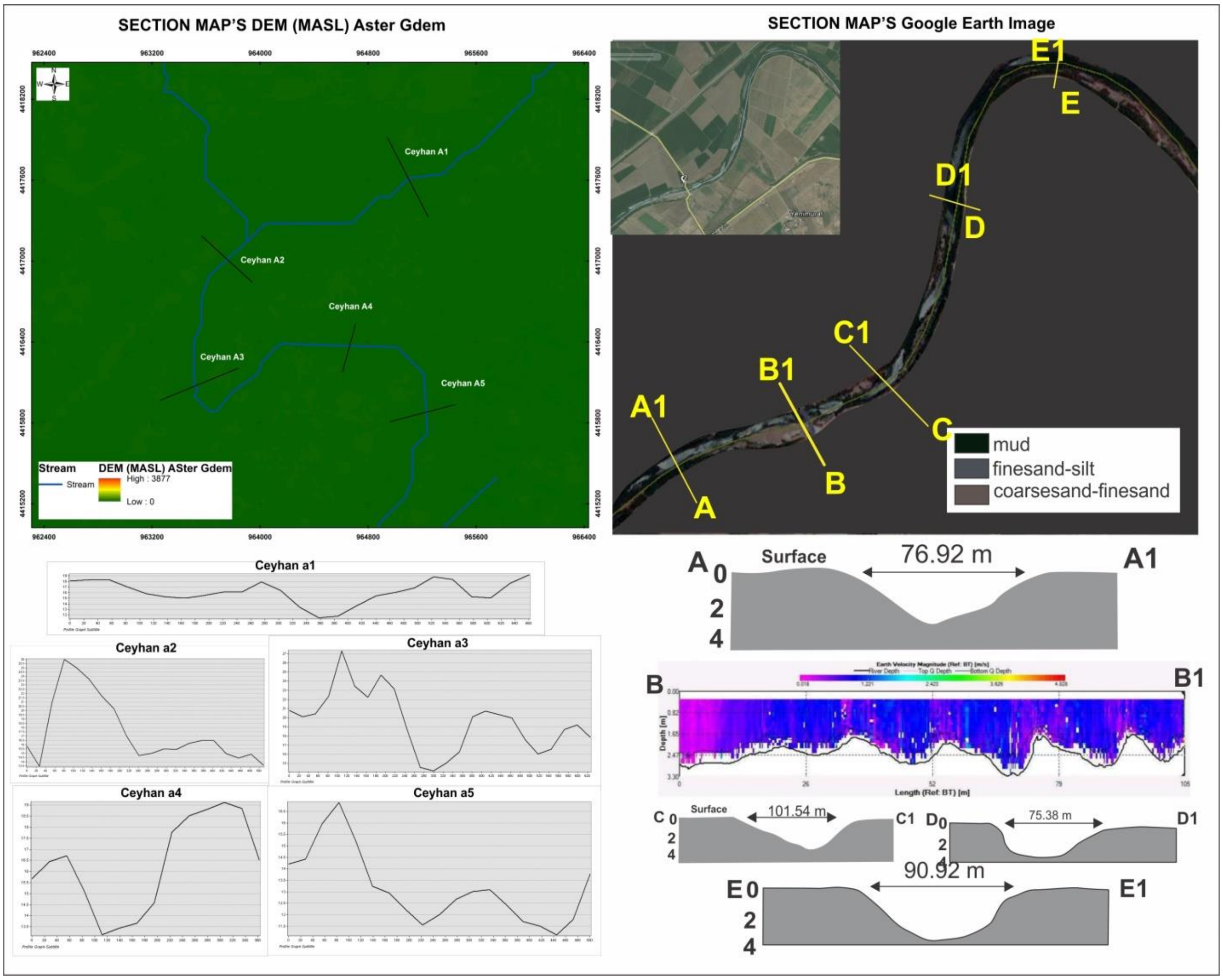

Figure 3. a) Bathymetric section map interpretation of meandering river in Seyhan river Yenimurat areas (section B-B1 courtesy from Ekoton Adana Rapport 2012); b) sediment distribution interpretation map shows various materials inside bankfull channel along valley.

Bedload indicates to mixed load channel where channel lowest points along the entire length of stream bed was covered by mud and silt which probably to sand. Heterogeneous grain sediments inside sinuosity channel suggested channel condition from mixed load transport river (Figure2). Boundary conditions is valley slope and topography based on interpretation at figure A-E with depth average 0-3 m, and variables or channel morphology. c) River cross-sections interpretation of channel that result symmetric and asymmetric cross-section and the location of B-B1 which scour at base of the banks. Topography model of Ceyhan river (right) was created by ASTER GDEM that show similarity shape. River may present more complicated forms of change where leading in some conditions to cut-off of bend, and development of ox-bow or abandoned channel loop. Cross-sections can provide clear evidence for progress of shoaling and may help diagnose the onset of bank erosion and meandering.

Quaternary sediments in the upstream to downstream of the Seyhan River had high sinuosity or meandering river systems (SI > 1) and Ceyhan River in the upstream had low-sinuosity rivers (SI=1 to 1.1). Observation in downstream area where channel related bedrock incision and misis high structures that different condition with Seyhan River which quaternary deposit and structures in the downstream area. External factors include structural activity near river where major controlled by NE-SW trending main faults zone (Kozan, Amanos-Larnaka and Misis-Kyrenia faults). Topography of continental shelf is less than 5 km wide but widens significantly more than 45 km southwest Adana. River inherited from past processes influence for river (Seyhan, Ceyhan, Tarsus which a major silisiclastic distribution into Adana Basin) that operated in delta complex (Aksu et al, 2014).

5.APPROACH TO SUBSURFACE DIMENSIONS

Image of seismic can describe paleogeography fluvial morphology dimension that very useful in modern imagination and comparison. It can give view vision of channel distribution and depositional geometry of facies from surface to subsurface (Posamentier, 2001) where seismic geomorphology compared with modern analogue from Seyhan and Ceyhan River. Enhancement interpretation channel dimension of fluvial reservoirs is significant tools especially for characterization of reservoir in hydrocarbon exploration. Lithological and textural variation is principally to decide distribution of permeability and porosity in sand body's reservoir (Davis et al., 1993). Thickness and width of sand bodies is utilities of hydraulic character of the river. Dimensional or sequence is preserved as vertical variations in reservoir. Short-range hydraulic variations in fluvial systems is replicated by intra-reservoir variation in sedimentary structures, grain size and shale contents.

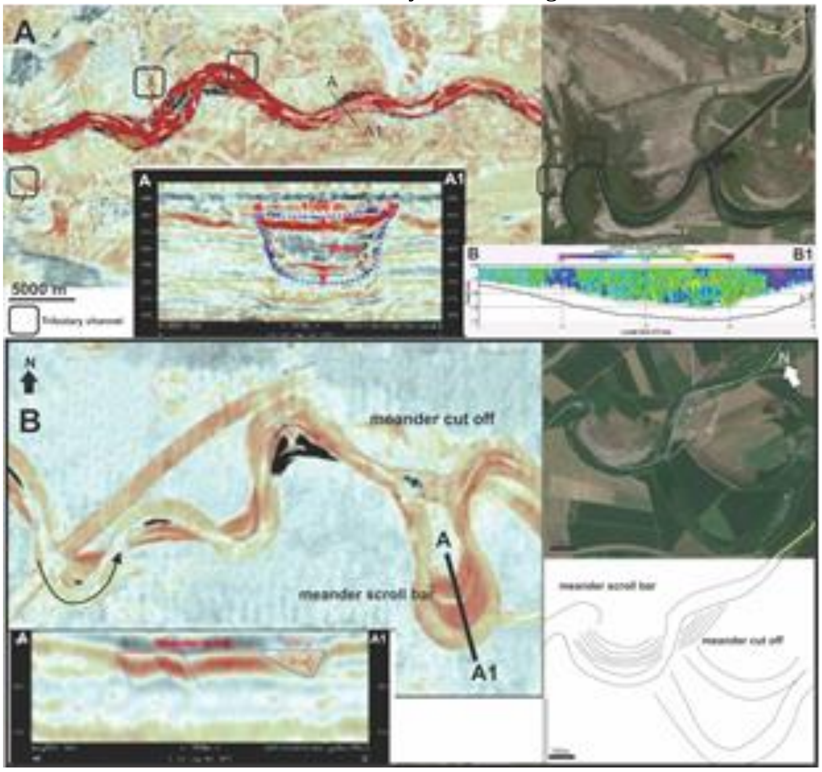

Figure 4a. 3D Image seismic of mid-upper Miocene in West Natuna Basin on time slices (335 ms) as example meander channel system and (B) Low-sinuosity of channel system of Upper Miocene, West Natuna Basin (time slice, 146 ms) that display meander cut off and scroll bars which compare with modern meander scroll bar and cut of in Seyhan River. (Fachmi and Wood, 2005 in Rohmana, R,C et al 2014) that compare with modern meander channel in Seyhan River.

In Seyhan River, data of earth velocity magnitude (Ekoton-Adana Rapport 2012) displayed bathymetric river ray last transcent that collected from Demirkopru (upstream), Tuzla and Baharli (downstream). Earth velocity magnitude of various river depths shows 3.75 until 7.1 m which compared geomorphological seismic slice (Figure 4).

Modern analogs require statistical constraints for data input in geomorphology object with reservoir models. All DSI wells mentioned in this paper is modified from (Kemal Gürbüz 1999), sedimentation rate indicate that relatively thick sediment with flood plain and geometry shape, channel sand body and geometry shape laterally continuous with interconnectivity interpretation on the base (Figure 5). Top interpretation succession and relatively thin and narrow in quaternary deposit. The log show a vertical transition from tidal influence sand bodies to narrow solitary sandstone bodies, from the base to the top of log interval. Narrow channel-like despairs happen in the middle and base of the J1-J2 sandstone bodies, which is not seen at J6-J7 that show intertidal influence (Figure 5). These channels are commonly 50->100 m wide, as much as 10–30 m deep, and interconnected in some interval. It occurs as solitary or more commonly amalgamated fluvial sandstone bodies, which varying thickness. The different sedimentation with low sedimentation is less sedimentation but more easily interconnected sand. Sequence interpretation during transgressive which base-level moves to landward, therefore confine fluvial erosion and produces high sinuosity (meandering). Transgressive sediments in downstream area creates a high width-depth ratio of channel morphology. Shallow fluvial system where transgressive surface (TS) deposit deliver seal of sediments that shale and very fine-grained. Carbonates layer (Figure 5) indicate maximum flooding after long transgressive system, the sequence respectively tidal influence to fluvial. Low and floodplain progress is controlled by sediments in suspension and deposited through floods.

6.CONCLUSIONS

Channel application of existing numerical models of sediment transport needs to calibrate an error in measurement to the local conditions and field, and less of data on sediment transport rates either suspended or bed load. Seyhan and Ceyhan River indicated meandering river from numerical calculation and observation. Earth images and DEM is useful to give a dimension as analogue to compare seismic with to identify the paleo-fluvial dimensions. Morphometric quantification gives information for ancient fluvial rivers morphology, lateral facies associations, lithological contents and regional control affected to geometry space basin and supply. Quantitative is one of support data for geologic interpretation that is useful in distribution reservoir, sequence stratigraphy, correlation, dimension channel, sand bodies and prediction.

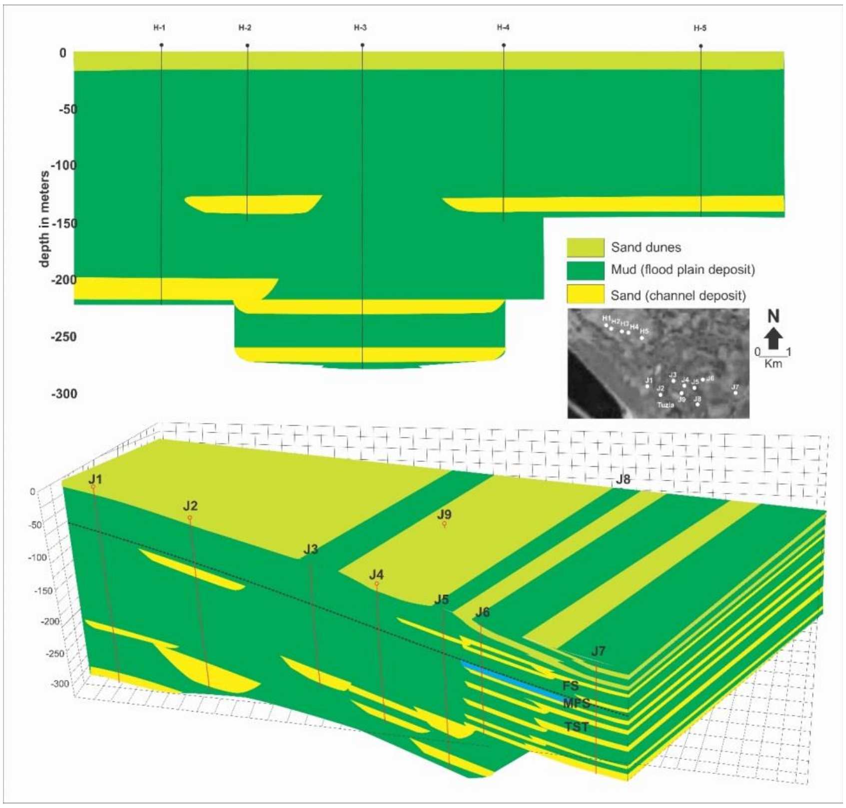

Figure 5. 3D model correlation of well J1-J8 modified from Gürbüz (1999), (upside) well correlation H1-H5 where H3 indicated other channel in the bottom that show interconnected sand. (Bottom side) The sequence of J1-J8 interpretation of flooding surface present when long transgressive that showed carbonate layer there**.**

ACKNOWLEDGMENTS

We thank to Ekoton Ankara, Data published in Adana Rapport 2012, we only used 2 section of river. Thanks to DSI Well information (Kemal Gürbüz 1999). We got information about sand body after made good interpretation and modeling from DSI Well.

REFERENCES

Aksu, A.E., Calon, T.J., Hall, J., Burton, R., 2005.Origin and evolution of the Neogene Iskenderun Basin, Northeastern Mediterranean Sea. Mar. Geol. 221, 121–159

Aksu. (2014). The Pliocene-Quaternary tectonic evolution of the Cilicia and Adana Basins , eastern Mediterranean : Special reference to the development of the Kozan Fault zone, (December 2015). http://doi.org/10.1016/j.tecto.2014.03.025

Allen, J. R. L., 1965, A review of the origin and characteristics of recent alluvial sediments: Sedimentology, v. 5, p. 89 – 191.

Allen, J. R. L., 1982, Sedimentary structures: their character and physical basis: Amsterdam, Elsevier, v. 2, 663 p

Burton-Ferguson, R., Aksu, A.E., Calon, T.J., Hall, J., 2005.Seismic stratigraphy and structural evolution of the Adana Basin. Eastern Mediterranean. Mar. Geol. 221, 189–222

David A. Sear, Malcolm D. Newson, and Colin R. Thorne, 2003, Defra/Environment Agency Flood and Coastal Defence R&D Programme, Reprinted by Defra Flood Management Division Ergon House 17 Smith Square, London, 253 p

Davies, K.P., Williams, B. P. J., Vessell, K.P., 1993, Dimensions and Quality of Reservoirs Originating in Low and High Sinuosity Channel Systems, Lower Cretaceous Travis Peak Formation, East Texas, USA, Geological Society, London, Special Publications, v.73, p. 95-121.

DSI, 1984. General Directory of State Waterworks (Devlet Suİşleri Genel Müdürlüğü). Elektrikİşleri Etüd İdaresi Genel Direktörlüğü (1984 Water Year Discharges, 209 pp.).

Ekoton Adana, Raporu, 2012, Nisan Ekoton Adana Raporu, Ankara Turkey, www.ekoton.com.tr

Erinc , S. 1953.About alluvial morphology of Cukurova. (in Turkish with English abstract) Istanbul University, Institute of Geography Bulletin3-4, 149±159

Fachmi, M., Wood, L.J., 2005, Seismic Geomorphology : A Study from West Natuna Basin, Indonesia, Proceeding 30th Annual Convention & Exhibition, Indonesian Petroleum Association, Jakarta.

Goney, S. 1976.Plains of Adana.I stanbul University, Institute of Geography Bulletin 88, 179 pp Schumm, S A 1977 The fluvial system, Wiley, New York.

Gürbüz, K. 1999. An example of river course changes on a delta plain : Seyhan Delta (Çukurova plain , southern Turkey). Geological Journal, Geol J 34(1999), 211–222. http://doi.org/10.1002/(SICI)1099-1034(199901/06)34

H. Rosyadi, 2016, Geomorphology and Quantitative Approach to Early Surface Data and Subsurface Representation Seyhan and Ceyhan River, Adana Basin, Turkey, TURQUA, Istanbul, Turkey. 8-11 May Geomorphology: An approach to determining subsurface reservoir dimensions (PetroTel Inc., Suite 207) 5240 Tennyson Parkway, Plano, Texas 75024;rtye@petrotel.com

Leopold, L. B., M. G. Wolman, and J. P. Miller, 1964, Fluvial processes in geomorphology: San Francisco, W. H. Freeman and Company, Reprinted by Dover Publications, New York, 1995, 522 p

Lewin, J 1976 Initiation of bed forms and meanders in coarse-grained sediment, Bulletin of the Geological Society of America, 87, 281-5.

Montgomery, D.R., 1999. Process domains and the river continuum. Journal of the Ameran Water Resources Association, 35(2): 397-410.

Nichols, G.J., Fisher, J.A., 2007, Processes, Facies and Architecture of Fluvial Distributary System Deposits, Journal of Sedimentary Geology, Elsevier, v.195, p.75-90.

Posamentier, H.W., 2001, Lowstand Alluvial Bypass Systems : Incised vs. Unincised, AAPG Bulletin, V.85, No.10, pp. 1771-1793.

Rohmana, R,C., Fardiansyah, I., Budiman, A., Irwanto, H., Jaya, I., Dewi, F, P., 2014, The Influence of Base-Level Change to Fluvial Morphology : Application to Exploration Concept of Hydrocarbon Play Using Analog Stream Table Experimental Landscape (STEX), Proceeding The 38th Annual Indonesian Petroleum Association (IPA) Convention & Exhibition, Jakarta, Indonesia, 21th – 23th May

Rohmana, R,C., Fardiansyah, I., Budiman, A., Malda, O., Taufani, L., Yessica, P., Prisila, J., 2014, Quantitative Application of Fluvial Geomorphology: Insight Into Modern Equatorial River of Borneo, Indonesia, Seminar Nasional Kebumian UGM, Yogyakarta, 30th-31th October.

Rust, B R, 1978 A classification of alluvial channel systems, in Miall, A D (Ed) Fluvial Sedimentology, Canadian Society of Petroleum Geologist Memoir, 5, 187-198.

Rust, B R, 1978 A classification of alluvial channel systems, in Miall, A D (Ed) Fluvial Sedimentology, Canadian Society of Petroleum Geologist Memoir, 5, 187-198.

Thorne, C R 1997 Channel types and morphological classification, in Thorne, C R, Hey, R D & Newson, M D (Eds) Applied fluvial geomorphology for river engineering and management, J.Wiley & Sons, Chichester, UK, 175 – 222.

Walsh-Kennedy, S., Aksu, A.E., Hall, J., Hiscott, R.N., Yaltırak, C., Çifçi, G., 2014.Source to sink:The development of the latest Messinian to Pliocene–Quaternary Cilicia and Adana Basins and their linkages Mut Basin, eastern Mediterranean. Tectonophysics 622, 1–21