

**Internal architecture, geometry and reservoir characterisation of
depositional lobes in outcrop and subsurface:
examples from S-Turkey and the North Sea.**

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ZUSAMMENFASSUNG

Nicht-kanalisierte, sandige Tiefwasserablagerungen, allgemein *lobe deposits* („Lobus-Sedimente“) nach Mutti & Normark (1987) benannt, sind ein grundlegendes Element vieler submariner Tiefseefächer und verwandter Turbiditsysteme. Ihr Kohlenwasserstoffpotential ist von ökonomischem Interesse und ein gutes Verständnis ihrer Faziesbeziehungen, Geometrie und Reservoirqualität sind unabdingbar für eine zielgerichtete Exploration und Produktion. Es hat sich jedoch gezeigt, dass die strikte Anwendung des ursprünglichen Begriffs *lobe deposits* zu restriktiv ist, um die Vielfalt der beobachteten lateral weit aushaltenden, nicht-kanalisierten sandigen *lobe deposits* zu umfassen. Eine weiter gefasste Definition dieser Ablagerungen hat in den letzten Jahren an Akzeptanz gewonnen.

Der E-Fan der Mittel-Miozänen Cingöz Formation (Südtürkei) ist ein bis dato wenig untersuchtes Beispiel eines regressiven, extrem sandreichen von mehreren Quellen gespeisten klastischen Tiefwassersystems, das in einem Trippelpunkt *escape basin* liegt und von dem aufsteigenden Taurus Orogen gespeist wird. Zeit-stratigraphische Veränderungen des E-Fan führten von einem konglomeratdominiertem System im späten (?) Burdigalian zu einem sanddominierten System im späten Burdigalian – Langhian, wo Sande hauptsächlich in mächtigen, lateral weit aushaltenden *lobe deposits sensu lato* abgelagert wurden. Charakteristische Komponentenassoziationen des *channel-lobe* Übergangs (Lobe A), der proximalen (Lobe B) und distalen (Lobe C) Ablagerungszonen, zeigen einen ausgeprägten strömungsabwärtsgerichteten Trend im Ablagerungsmuster. Wechselnde räumliche und zeitliche Ablagerung deutet tektonische Aktivität als einen bestimmenden Mechanismus an, der das Muster der Sedimentzufuhr und die Beckentopographie kontrollieren, was zu einer begrenzten Geometrie und aggradierend-gestapelten *lobe deposits* führt, die das Ergebnis von niedrig- und hochkonzentrierten, sandreichen Trübe- und sandigen Schuttströmen im Sinne von Shanmugam (1996) sind. Auffallendes *fining upward* der Loben- und des Turbiditsystems, dokumentiert einen allmählich ansteigenden Meeresspiegel, wohingegen vereinzelte Progradations-Phasen und/oder der Eintrag grobklastischer Sedimente auf höherfrequente Meeresspiegelschwankungen oder tektonische Bewegungen des Hinterlandes schließen lassen.

Der S10 Interval des Scapa Sandstone Members (U-Kreide, Scapa Field, UK block 14/19, North Sea) ähnelt nach Reading & Richards (1994) einem von mehreren Quellen gespeisten tonig/sandreichen bis sandreichen submarinem Rampensystem, mit einigen *slope apron* Merkmalen, das sich während steigendem Meeresspiegel entwickelte. Sedimente wurden am von Konglomeraten umsäumte Halibut Schelf vorbei geleitet und durch ein verzweigtes Kanalsystem tiefer in das Scapa Becken verteilt. Die Masse der Sande wurde in gering bis unkanalisierten, sandigen *lobe* und *lobe fringe deposits* sedimentiert. Die *lobes* sind hauptsächlich aus sandigen, hochkonzentrierten und verdünnten Trübeströmungen und wahrscheinlich auch sandigen Schuttströmen (Shanmugam 1996) aufgebaut. Ihre Position und Geometrie deutet auf einen starken Einfluß des Liefergebietes hin. Grabentektonik führt zu lokaler, Lobenaggradation mit oftmals länglicher Geometrie, was auf einen begrenzten Ablagerungsraum hindeutet.

Die makro- und megaskopische Reservoircharakterisierung der Cingöz *lobe deposits* macht ihr Potential als Explorationsziel deutlich, besonders wegen ihrer großflächigen Ausdehnung, dem generellen hohen Nettosandgehalt und der extrem guten vertikalen und lateralen Konnektivität. Migrationsbarrieren, wie zum Beispiel Tonlagen, sind in den proximalen Bereichen (Lobe A/B) nicht vorhanden und treten nur in einer strömungsabwärtsgerichteten Richtung auf. Sie führen zu einer Kompartimentalisierung des distalen Reservoirs (Lobe C). Jedoch zeigt sich, dass Diagenese die Reservoirqualität entscheidend negativ verändern kann, wie zum Beispiel in den *lobe deposits* des Scapa Felds, wo stark variierende Zementation zur Reservoirkompartimentalisierung führt.

ABSTRACT

Non-channelized, sandy deep-water deposits, commonly termed lobe deposits *sensu* Mutti & Normark (1987), form an elemental building block of many submarine fans and related turbidite systems. They possess an important hydrocarbon reservoir potential and a clear understanding of their geometry, facies relationships and reservoir quality are imperative for effective exploration and exploitation. However, the *sensu stricto* definition proves to be too restrictive to embrace the great variety of the laterally extensive, non-channelized, sandy depositional bodies observed and in recent years a broader, in essence *sensu lato* definition has gained acceptance.

The E-Fan of the Mid-Miocene Cingöz Formation (southern Turkey) is a to date little studied example of a regressive, extremely sand-rich, multi-sourced deep-water clastic system deposited in a triple junction escape basin sourced from the emerging Tauride Orogen. Time-stratigraphic changes show that the E-Fan system evolve from a gravel-dominated system during late? Burdigalian to a sand-dominated one in late Burdigalian – Langhian times where the bulk of the sand accumulated in thick, laterally extensive, sandy lobes *sensu lato*. Unique component associations characterise the channel-lobe transition (Lobe A), proximal (Lobe B) and distal (Lobe C) depositional zones, recording a distinct downcurrent change in sedimentation pattern. Changing spatial and temporal deposition indicates tectonism as the fundamental mechanism controlling the sediment supply pattern and basinfloor topography which is reflected in the confined geometry and aggradational stacking of the lobes. They are the products of deposition by low- and high-density sand-rich turbidity currents and possibly sandy debris flows *sensu* Shanmugam (1996). Conspicuous fining upward at lobe- and system- scale document the gradually rising sea level while sporadic phases of progradation and/or coarse clastic sediment supply imply higher frequency sea-level fluctuations and tectonically-driven source area control.

The S10 interval of the Lower Cretaceous Scapa Sandstone Member (Scapa Field, UK block 14/19, North Sea) is akin to a multiple sourced mud/sand-rich to sand-rich submarine ramp system *sensu* Reading & Richards (1994) with some features of a slope apron system developing during times of gradual sea-level rise. Sediment bypassed the conglomerate-fringed Halibut Shelf and funnelled further into the Scapa sub-basin by a distributary channel system. The bulk of the sand-grade material was deposited in little to non-channelized, detached sandy lobe and lobe fringe deposits. Lobes are mainly composed of sandy high-density turbidity currents and diluted flows and possibly sandy debris flows *sensu* Shanmugam (1996). The location and geometry of the lobe deposits is strongly determined by source-area and basinal tectonism which led to localised, stacked, aggradational lobe accumulation of elongate geometry indicating that deposition was restricted.

The macro- and megascopic reservoir characterisation of the Cingöz lobe deposits clearly shows their attraction as exploration target due to their great areal extend, the overall high net sand content and the extremely good vertical and lateral connectivity. Flow barriers, such as shale layers, are absent in the most proximal areas (Lobe A/B) and only appear in a down-current direction, compartmentalising the distal reservoir (Lobe C). However, diagenesis may have an overriding effect on the reservoir quality as documented in the S10 lobe deposits where varying degrees of cementation are responsible for reservoir compartmentalisation.