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Research paper

Neogene history of Bone Gulf, Sulawesi, Indonesia

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ABSTRACT

Bone Gulf is one of the inter-arm basins of the unusual K-shaped island of Sulawesi. Its age, character and origin are disputed. This study is based on recently acquired 2D seismic lines, seabed multibeam mapping and limited well data, and is linked to stratigraphy on land. The gulf is probably underlain by pre-Neogene volcanogenic, sedimentary, metamorphic and ultramafic rocks, and includes crust of Australian origin. We favour basin initiation in the Miocene rather than Eocene, by extension associated with strike-slip deformation. The main basin trends N–S and is divided into several sub-basins and highs. The highs segment the gulf and their WNW–ESE orientations reflect pre-Neogene basement structures. They are interpreted as strike-slip fault zones active at different times in the Neogene. A southern high was active relatively early, whereas further north there is evidence of young displacements during the Late Neogene. These are visible on the seabed above a high linked to the Kolaka Fault on land. Early basin-bounding faults are oriented NNW–SSE and record extension and strike-slip movements, like the sub-parallel Walanae Fault of South Sulawesi which can be traced offshore into extensional faults bounding the young and narrow Selayar Trough. Sediment in the basins came mainly from the north with contributions from both west and east. Carbonate deposits formed at the margins while deeper marine sediments were deposited in the axial parts of the gulf. An Early Pliocene unconformity can be mapped across the study area marking major uplift of Sulawesi and subsidence of Bone Gulf. This regional event caused major influx of clastic sediments from the north, development of a southward-flowing canyon system, and back-stepping and drowning of carbonates at the basin margins. Hydrocarbons are indicated by seeps, and Bone Gulf has potential sources, reservoirs and seals, but the complex faulting history is a risk.

1. Introduction

Bone Gulf is located between the South and SE Arms of Sulawesi and occupies an area of approximately 50,000 km^2 (Fig. 1). It opens into the Flores Sea to the south, which joins the Banda Sea further east. The centre of the gulf, where water depths reach 1800 m, is surrounded by a narrow shelf that rarely exceeds 25 km in width. Active hydrocarbon exploration blocks are shown on Figure 2. Proven petroleum plays include gas fields in stratigraphic traps in the East Sengkang Basin (Fig. 2) on the South Arm and oil shows and discoveries in and around the island of Buton at the tip of the SE Arm. Oil seeps are reported offshore near Kolaka (Thompson et al., 1991) and to the southwest of Bone Gulf (Thompson et al., 1991; Noble et al., 2009) near the southern edge of the study area (Fig. 1). The source of these seeps is unknown. There is a single well, BBA-1X, in the northern part of the Gulf (Fig. 2) and until recently only a small number of regional seismic lines crossed the Gulf (Sudarmono, 2000; Yulihanto, 2004).

The South Arm of Sulawesi is generally considered to be the eastern margin of Sundaland which includes continental fragments (e.g. Wakita et al., 1996; Parkinson et al., 1998) that rifted from Australia in the Jurassic and accreted to Sundaland in the Cretaceous (Hall et al., 2009; Hall, 2012). The South Arm (Sukamto, 1975a, 1982; Sukamto and Supriatna, 1982; Djuri et al., 1998) is cut by the Walanae Fault (Fig. 3) which is often interpreted as a sinistral strike-slip fault (Sukamto, 1975b) but is reported to show significant vertical displacement (Grainge and Davies, 1985; van Leeuwen et al., 2010). To the west of the fault zone, a Paleogene volcanic succession is overlain by the Tonasa carbonate platform which is succeeded by volcanic and volcaniclastic rocks of the Camba Formation that contributed to drowning of the platform in the Miocene (Wilson, 1996, 2000). In the Bone Mountains to the

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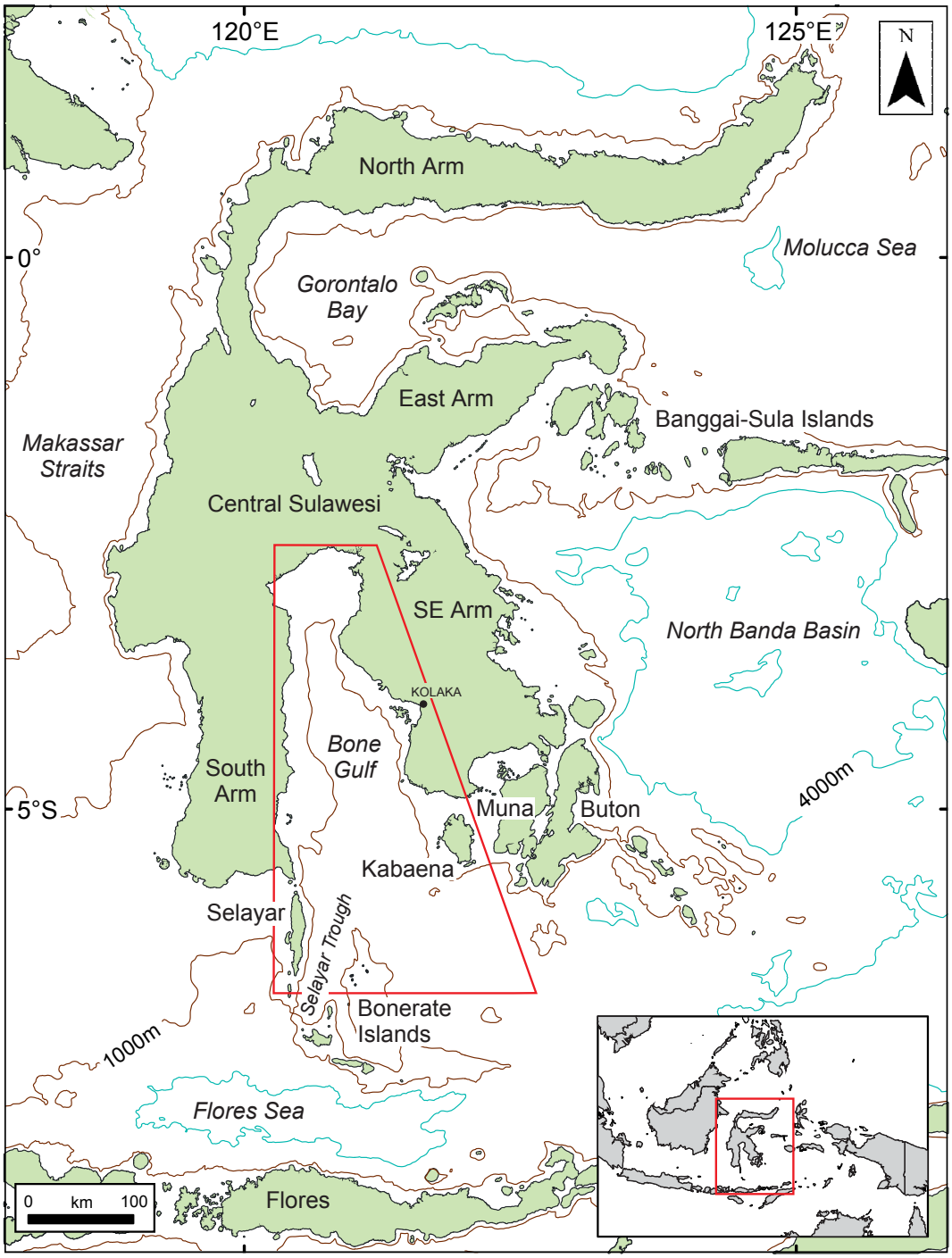

Figure 1. The location of Bone Gulf between the South and SE Arms of Sulawesi. Bathymetry from Gebco (2003). Water depths reach c. 2.5 km in the deepest parts of the gulf. The study area is outlined in red. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

east of the fault zone, volcanic and volcaniclastic rocks of Middle Eocene to Early Miocene age (van Leeuwen et al., 2010) are unconformably overlain by the Middle Miocene Camba Formation and lateral equivalents which are covered by Middle Miocene to Recent shallow marine carbonates and clastic sediments. A similar sequence is reported from the SE tip of the South Arm and on the island of Selayar (Sukamto and Supriatna, 1982).

The SE Arm (Rusmana et al., 1993; Simandjuntak et al., 1991, 1993a,b) and the islands of Kabaena, Muna and Buton (Fig. 1) are underlain (Fig. 3) by Mesozoic sedimentary rocks, Palaeozoic to Cenozoic metamorphic rocks and ultramafic rocks (de Roever, 1947; Hamilton, 1979; Davidson, 1991; Smith and Silver, 1991; Wijbrans et al., 1994; Milsom et al., 1999). These rocks are unconformably overlain by Miocene to Recent clastic and carbonate sedimentary rocks (Surono, 1994, 1998). The origin of the SE Arm is complex. It is interpreted to include continental rocks of Australian origin. A common view interprets the SE Sulawesi and Buton region to be the product of multiple broadly E–W collisions of microcontinents in the Late Paleogene and Early Neogene (e.g. Fortuin et al., 1990; Davidson, 1991; Smith and Silver, 1991; Satyana and