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Debate
Lithostratigraphy of volcanic and sedimentary sequences in central Livingston Island, South Shetland Islands

Discussion

ANTONI K. TOKARSKI and MAREK DOKTOR

Institute of Geological Sciences, Polish Academy of Sciences, Senacka 1-3, 31-002 Krakow, Poland
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Comment on the paper Lithostratigraphy of volcanic and sedimentary sequences in central Livingston Island, South Shetland Islands by J.L. Smellie, M. Liesa, J.A. Muñoz, F. Sàbat, R. Pallas & R.C.R. Willan (*Antarctic Science*, 7, 99–113)

In the paper summarizing lithostratigraphy in central Livingston Island, Smellie *et al.* (1995) criticized and rejected our recent proposal (Doktor *et al.* 1994) concerning the restriction of the Miers Bluff Formation (MBF) to the lowermost part of the sequence exposed at Hurd Peninsula. Within this part of the sequence, we have mapped (Doktor *et al.* 1994) three subunits, named by us, in ascending order: South Bay Mb., Johnsons Dock Mb. and Glacier Rocoso Mb. These members are lithologically distinct, are easy to trace in landscape and, in our interpretation, correspond to different sedimentological settings. Our results were questioned by Smellie *et al.* (1995) who doubt the continuity of these members across the central ice cap. In our opinion, the possibility that the three members do not continue across the ice cap is insignificant. First, on both sides of the ice cap, the same succession of three identical rock bodies crops out. Second, for the South Bay Mb., there is no gap in outcrop along the strike, and the gap across the strike is only about 200 m wide, whereas the member is more than 850 m thick. Therefore the continuity of the South Bay Mb. can hardly be questioned.

Furthermore, in the Antarctic Peninsula region, outcrops are usually discontinuous being separated by ice or water. It follows that if we accept the Smellie *et al.* (1995) reasoning, we can hardly accept any lithostratigraphy in this region. On the other hand, we believe that the subdivisions introduced by us give some clues to the origin of the MBF.

Moreover, Smellie *et al.* (1995) grouped three members distinguished by Doktor *et al.* (1994) into a single unit which they named Johnsons Dock Mb. The name Johnsons Dock Mb. was introduced by Doktor *et al.* (1994), and the proposition of Smellie *et al.* (1995) leads to confusion.

We do not share the opinion of Smellie *et al.* (1995), that the previous studies in the central part of Livingston Island were of reconaissance nature only. In our paper (Doktor *et al.* 1994) we presented a 1:50 000 map of the western part of Hurd Peninsula and we discussed in detail lithology, petrography and tectonics of this area.

According to Smellie *et al.* (1995), a geographical association of the MBF with a magmatic arc is undisputed. In our study of the MBF (Doktor *et al.* 1994), we found no traces of contemporaneous extrabasinal volcanism and therefore we suggested the association of the MBF with an inactive margin. According to Smellie *et al.* (1995) the strata of the MBF dip at *c.* 45°. This is highly oversimplified as the strata of the MBF dip from 0–90° (Muñoz *et al.* 1992 - fig. 2, Doktor *et al.* 1994 – fig. 3).

Reply

ROBERT C.R. WILLAN[1], JOHN L. SMELLIE[1], FRANCESC SÀBAT[2] and JOSEP A. MUÑOZ[2]

[1]*British Antarctic Survey, NERC, High Cross, Madingley Road, Cambridge CB3 0ET, UK*
[2]*Universitat de Barcelona, Facultat de Geologia 08028 Barcelona, Spain*
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Tokarski & Doktor point out several areas of disagreement between two recent papers on the stratigraphy, provenance and structure of the Miers Bluff Formation (MBF), Livingston Island (Doktor *et al.* 1994, Smellie *et al.* 1995). Unfortunately, the paper by Doktor *et al.* was communicated to us at a late stage, and the similar timing of the two papers has led to confusion in stratigraphical nomenclature.

We see no reason to redefine the Miers Bluff Formation (Dalziel 1972) by restricting it to the lowermost 1600 m of turbidite rocks in west Hurd Peninsula. We have mapped the MBF for 7.5 km between Binn Peak and Napier Peak and at Burdick Peak 6 km to the NE. Doktor *et al.* (1994) acknowledged that their fieldwork was confined to west Hurd Peninsula and that they did not examine the stratigraphical top of the MBF.

Our *minimum* thickness of 3 km for the MBF was calculated along a line striking N120°E between Henry Bluff and False Bay, and agrees with the original definition of the Miers Bluff Formation (Hobbs 1968, Dalziel 1972). An upper limit to the formation is seen on False Bay where interbedded sandstones and thin-bedded siltstone/mudstone alternations (called rhythmites by Doktor *et al.* 1994) are present 40–80 m above sea level. Nearby, volcanic megabreccias contain large boulders of deformed MBF (Willan 1996 in press); a less precise outcrop limit occurs between Moores Peak and Williams Point where ?Cretaceous volcanic rocks contain MBF detritus (Smellie *et al.* 1995).

Subdivision of the lower 1600 m into three members relies upon the lateral continuity of a 150 m-thick mudstone-

dominated facies (Johnsons Dock Member) separating the South Bay Member (SBM, base not exposed) and the Glacier Rocoso Member (GRM, top not examined). Doktor *et al.* claimed that the JDM may be traced for 6 km between two sections — near Sally Rocks and at Johnsons Dock. We find this tripartite division difficult to accept for these reasons:

1) The southern section (Sally Rocks) of the JDM consists of a thick (40 m) rhythmite sequence whereas the northern section (Johnsons Dock) consists of three thick (up to 25 m) mudstones interbedded with 10 m-thick sandstones, i.e. the two mapped sections are lithologically different. Most of the intervening 6 km lies under ice (4.5 km) or boulder field, hence a lithological correlation of the Sally Rocks and Johnsons Dock sections is weakly founded.

2) Similar thick rhythmite and mudstone units are present at other levels for example, mudstones up to 20m thick occur in the SBM at Salisbury Bluff and rhythmites and mudstones (up to 40 m) occur in the GRM at MacGregor Peaks, near Moores Peak and at Cerro Mirador.

3) We observed thick sequences of massive sandstone and intra-formational conglomerate in the proposed GRM on southeast Hurd Peninsula. Hence, there is little lithological contrast between the SBM and GRM - they are typical of the MBF as a whole.

4) The MBF has been interpreted as channel-fill, overbank and lobe deposits in a turbidite-fan setting. Rapid facies changes along- and across-strike are probable, making lateral correlation between distant points unreliable without distinct marker beds and continuous exposure.

5) In the Johnsons Dock area, there are minor faults, fractures, orientated mineral-growth textures in veins, and dyke swarms, indicating a SE-trending shear fault through the inlet (Willan 1994). Coastal topography, and changes in lithology (on east Hurd Peninsula), suggest that several ESE- or SE-trending faults cross Hurd Peninsula. Doktor *et al.* show an abrupt disappearance of the JDM against a SE-striking fault near Binn Peak. Individual beds have not been traced across the ice-covered gaps in exposure. Therefore, it is not possible to assume along-strike continuity for most of the JDM and GRM outcrop.

6) Doktor *et al.* argued that the JDM weathers recessively, resulting in areas of topographical flattening which may be mapped along the length of Hurd Peninsula. However, this association is not seen at Johnsons Dock where the JDM rises from near sea-level to Monte Reina Sofia at 274 m. The flat area near Sally Rocks also cuts across different lithologies of the SBM. The larger flat areas forming Polish, Henry and Salisbury bluffs also show a poor correspondence with underlying lithologies. We interpret these flat areas as marine platforms uplifted in the late Tertiary/Pleistocene (Pallàs *et al.* 1995).

We agree with Tokarski & Doktor that their sedimentary logs and lithofacies enable the depositional environment of the MBF to be clarified. However, their re-definition of the MBF is unnecessary and their vertical subdivision and lateral correlations are unconvincing. Correlation in a faulted, deformed, turbidite terrane requires distinctive lateral markers, faunal evidence, or radiometric ages. Unmatched sections occur in similar thick turbidite sequences elsewhere in the Antarctic Peninsula region. By contrast, successful lithostratigraphical mapping has been achieved in the more varied, and less deformed, fore- and back-arc basin sequences.

A geographical association with a magmatic arc is undisputed because all petrographical studies of the MBF indicate derivation from an eroded volcanic/plutonic terrane (see Smellie *et al.* 1995). However, we did not imply that the arc was active. Evidence of *contemporaneous* volcanism (shards, bedded tuffs, pyroclastic flows) has not been identified, and isotopic data suggest derivation of sedimentary detritus from the Palaeozoic fore-arc accretionary complex in southern South America (Willan *et al.* 1994).

Our description of the MBF as generally overturned and dipping to the north-west was intended only as an introductory sentence. This dominant, and regional, orientation is obvious from the scarp and dip topography on Hurd Peninsula as seen from a distance. In our paper, there followed almost a page of text describing four complex fold systems in which it is clear that the strata vary from horizontal through vertical to overturned.

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